JP-2001-20150E

[Title of the Invention] METHOD AND APPARATUS FOR MANUFACTURING LIQUID CRYSTAL DISPLAY APPARATUS

[Abstract]

[Object] An object of the present invention is to provide a method and apparatus for manufacturing a liquid crystal display apparatus capable of obtaining a higher display quality than a conventional method and apparatus.

[Solving Means] A vertically aligned liquid crystal 29 is inserted between a TFT substrate 10 and a CF substrate 20. A pixel electrode 16a on which a slit 15b is formed is formed on the TFT substrate 10 is formed, and a cell gap sustaining spacer 25a and a domain control protrusion 25b are formed on the CF substrate 20. For example, a positive type photoresist is coated on a common electrode 2. Next, by using a mask for shielding a spacer formation region and a protrusion formation region, a first exposure process is performed, and after that, by using a mask for shielding the spacer formation region, a second exposure process is performed. Next, by developing the photoresist, the spacer 25a and the protrusion 25b having different height can be simultaneously formed.

[Claims]

[Claim 1] A vertically aligned liquid crystal display apparatus where a vertically aligned liquid crystal is inserted into a pair of substrates, comprising:

a cell gap adjustment spacer formed on at least one of the two substrates to maintain the cell gap in a constant value; and

a domain control protrusion formed on the substrate where the spacer is

formed and made of the same material as that of the spacer, wherein a height of the domain control protrusion is larger than that of the spacer.

[Claim 2] A method of manufacturing a vertically aligned liquid crystal display apparatus where a vertically aligned liquid crystal is inserted into a pair of substrates, comprising:

a photoresist film formation step of forming a photoresist film on one substrate;

an exposure step of transferring a spacer pattern and a protrusion pattern on the photoresist film by using a mask having the spacer pattern and the protrusion pattern in a condition that thickness of after-developing remaining films are different; and

a developing step of developing the photoresist film to form a cell gap adjustment spacer corresponding to the spacer pattern and a domain control protrusion corresponding to the protrusion pattern.

[Claim 3] A color filter for a liquid crystal display apparatus comprising:

a substrate;

a plurality of color filters having a plurality of colors formed on the substrate;

a common electrode formed on the color filters;

a cell gap adjustment spacer formed the common electrode; and

a domain control protrusion formed on the common electrode by using the same process and material as the cell gap adjustment spacer, wherein a height of the domain control protrusion is smaller than that of the cell gap adjustment spacer.

[Claim 4] A method of manufacturing a color filter for a liquid crystal display apparatus, comprising steps of:

forming a plurality of color filters having a plurality of colors on a substrate;

forming a common electrode made of a conductive material on the color filters;

forming a photoresist film on the common electrode;

transferring a spacer pattern and a protrusion pattern on the photoresist film by using a mask having the spacer pattern and the protrusion pattern in a condition that thickness of after-developing remaining films are different; and

developing the photoresist film to form a cell gap adjustment spacer corresponding to the spacer pattern and a domain control protrusion corresponding to the protrusion pattern.

[Claim 5] A method of manufacturing a vertically aligned liquid crystal display apparatus where a vertically aligned liquid crystal is inserted into a pair of substrates, comprising:

a photoresist film formation step of forming a photoresist film on one substrate;

an exposure step of transferring a spacer pattern and a protrusion pattern on the photoresist film by using a mask having the spacer pattern and the protrusion pattern, wherein a width of the protrusion pattern is smaller than that of the spacer pattern;

a developing step of developing the photoresist film to form a cell gap adjustment spacer corresponding to the spacer pattern and a domain control protrusion corresponding to the protrusion pattern;

a post-baking step of post-baking the after-developing photoresist film, thereby the height of the domain control protrusion being smaller than that of the cell gap adjustment spacer.

[Claim 6] A method of manufacturing a color filter for a liquid crystal display apparatus, comprising steps of:

forming a plurality of color filters having a plurality of colors on a substrate;

forming a common electrode made of a conductive material on the color filters;

forming a photoresist film on the common electrode;

transferring a spacer pattern and a protrusion pattern on the photoresist film by using a mask having the spacer pattern and the protrusion pattern, wherein a width of the protrusion pattern is smaller than that of the spacer pattern;

developing the photoresist film to form a cell gap adjustment spacer corresponding to the spacer pattern and a domain control protrusion corresponding to the protrusion pattern; and

post-baking the after-developing photoresist film, thereby the height of the domain control protrusion being smaller than that of the cell gap adjustment spacer.

[Claim 7] A method of manufacturing a liquid crystal display apparatus, comprising steps of:

forming a color filter on a first substrate;

forming an electrode made of a transparent conductive material on the first substrate;

forming a photoresist film on the transparent material;

forming a cell gap adjustment spacer and a domain control protrusion by exposing the photoresist film and then performing a developing process, wherein a height of the domain control protrusion is smaller than that of the cell gap adjustment spacer;

forming a first alignment film on a surface of the first substrate; and

attaching the first substrate to a second substrate having a pixel electrode and a second alignment film, and injecting a vertically aligned liquid crystal between the first and second substrates.

[Claim 8] A liquid crystal display apparatus having a black matrix formed by stacking color filters having at least two of red, green, and blue colors on a substrate,

wherein edges of at least two of red, green, and blue pixels is defined by an edge of an upper color filter.

[Claim 9] A color filter substrate for a liquid crystal display apparatus, comprising:

a substrate;

a red color filter formed on a red color pixel portion on the substrate;

a green color filter formed on a green color pixel portion;

a blue color filter formed on a blue color pixel portion; and

a black matrix formed by stacking at least two of the red, green, and blue color filters on a region between the pixels on the substrate,

wherein edges of the red, green, and blue pixels are defined by an edge of an upper color filter of the color filters constituting the black matrix.

[Claim 10] A method of manufacturing a liquid crystal display apparatus, comprising steps of:

forming a first color filter on a first color pixel portion and a black matrix formation portion on a substrate;

forming a second color filter on a second color pixel portion and the black matrix formation portion on the substrate and defining an edge of the first color

pixel portion by using an edge of the second color filter; and

forming a third color filter on a third color pixel portion and the black matrix formation portion on the substrate, defining an edge of the second color pixel portion by using an edge of the third color filter, and defining an edge of the third color pixel portion by using the edge of the first color filter.

[Claim 11] A method of manufacturing a color filter substrate for a liquid crystal display apparatus, comprising steps of:

forming a first color filter on a first color pixel portion and a black matrix formation portion on a substrate;

forming a second color filter on a second color pixel portion and the black matrix formation portion on the substrate and defining an edge of the first color pixel portion by using an edge of the second color filter;

forming a third color filter on a third color pixel portion and the black matrix formation portion on the substrate, defining an edge of the second color pixel portion by using an edge of the third color filter, and defining an edge of the third color pixel portion by using the edge of the first color filter; and

forming a common electrode made of a transparent conductive material on the color filters.

[Claim 12] A liquid crystal display apparatus where a liquid crystal is inserted between a pair of substrates,

wherein a first spacer for defining a cell gap between the substrates in a normal state and a second spacer having a height smaller than that of the first spacer are disposed between the two substrates.

[Claim 13] The liquid crystal display apparatus according to claim 12, wherein the first and second spacers are made of materials having different pressing

displacement.

[Claim 14] A liquid crystal display apparatus where a liquid crystal is inserted between a pair of substrates,

wherein a spacer for defining a cell gap between the substrates is constructed by stacking a plurality of film having different pressing displacement.

[FIG. 15] A method of manufacturing a liquid crystal display apparatus, comprising steps of:

forming a first photoresist film on a first substrate and performing an exposure process and a developing process on the first photoresist film, thereby selectively forming a first spacer on an inter-pixel region;

forming a second photoresist film on the first substrate and performing an exposure process and a developing process on the second photoresist film, thereby forming a second spacer having a height different from a height of the first spacer on a region where the first spacer is not formed; and

attaching the first and second substrates by contacting a distal end portion of one of the first and second spacers to the second substrate, and inserting the liquid crystal between the two substrates.

[Claim 16] A method of manufacturing a liquid crystal display apparatus, comprising steps of:

forming a spacer by stacking a plurality of film made of materials having different pressing displacement on a region between pixels on a first substrate; and

attaching the first and second substrates by contacting a distal end portion of the spacer to the second substrate, and inserting the liquid crystal between the two substrates.

[Claim 17] A method of manufacturing a liquid crystal display apparatus, comprising steps of:

forming a black matrix and a color filter on a first substrate;

forming a first photoresist film on an entire upper surface of the first substrate and performing an exposure process and a developing process on the first photoresist film, thereby forming a domain control protrusion on the color filter and selectively forming a resist resin film over the black matrix;

forming a second photoresist film on an entire upper surface of the first substrate and performing an exposure process and a developing process on the second photoresist film, thereby forming a first spacer made of the second photoresist film over the black matrix and a second spacer made of the resist resin film and the second photoresist film thereon;

attaching the first and second substrates by contacting a distal end portion of the second spacer to the second substrate, and inserting the liquid crystal between the two substrates.

[Claim 18] A method of manufacturing a color filter substrate for a liquid crystal display apparatus, comprising:

forming a black matrix and a color filter on a substrate;

forming a first photoresist film on an entire upper surface of the substrate and performing an exposure process and a developing process on the first photoresist film, thereby forming a domain control protrusion on the color filter and selectively forming a resist resin film over the black matrix; and

forming a second photoresist film on an entire upper surface of the substrate and performing an exposure process and a developing process on the second photoresist film, thereby forming a first spacer made of the second

photoresist film over the black matrix and a second spacer made of the resist resin film and the second photoresist film thereon.

[Claim 19] A method of manufacturing a liquid crystal display apparatus, comprising steps of:

forming a black matrix and a color filter on a first substrate;

forming a color filter on a pixel portion on the first substrate and forming a color filter on only a predetermined region of the black matrix;

forming a photoresist film on an entire upper surface of the first substrate and performing an exposure process and a developing process on the photoresist film, thereby forming spacers on the color filter stacked on the black matrix and on the black matrix where the color filter is not stacked;

attaching the first and second substrates by contacting a distal end portion of the spacer on the color filter to the second substrate, and inserting the liquid crystal between the two substrates.

[Claim 20] A method of manufacturing a color filter substrate for a liquid crystal display apparatus, comprising:

forming a black matrix on a substrate;

forming a color filter on a pixel portion on the substrate and forming a color filter on only a predetermined region of the black matrix;

forming a photoresist film on an entire upper surface of the substrate and performing an exposure process and a developing process on the photoresist film, thereby forming spacers on the color filter stacked on the black matrix and on the black matrix where the color filter is not stacked.

[Claim 21] A liquid crystal display apparatus comprising:

a pair of substrates;

a plurality of spacers for forming a gap between the substrates; and

a liquid crystal inserted into the substrates;

wherein, if a spacer distribution density is n (numbers/cm^2); if a displacement amount generated by exerting a force of 9.8/n (N) on one spacer is x; if an average interval between the substrates is d; if a liquid crystal density at a temperature of 60 □ is q_{60} (g/cm^3); and if a liquid crystal density at a temperature of - 20 □ is q_{-20} (g/cm^3), the following equation is satisfied:

$x/d > (1/q_{60} - 1/q_{-20})/(1/q_{60})$

[Claim 22] A liquid crystal display apparatus comprising:

a pair of substrates;

a plurality of spacers for forming a gap between the substrates; and

a liquid crystal inserted into the substrates;

wherein, if a spacer distribution density is n (numbers/cm^2); if a displacement amount generated by exerting a force of 9.8/n (N) on one spacer is x; if an average interval between the substrates is d; if a liquid crystal density at a temperature of 60 □ is q_{60} (g/cm^3); and if a liquid crystal density at a temperature of 20 □ is q_{20} (g/cm^3), the following equation is satisfied:

$x/d > 2^* (1/q_{60} - 1/q_{20})/(1/q_{60})$

[Claim 23] A liquid crystal display apparatus comprising:

a TFT substrate having a thin film transistor;

a CF substrate having a plurality of color filter having a plurality colors;

a liquid crystal inserted between the TFT and CF substrates,

wherein the TFT substrate comprises:

a transparent substrate;

the thin film transistor formed on the transparent substrate;

a final insulating protective film for coating at least the thin film transistor; and

a pixel electrode electrically connected to the thin film transistor at a portion where the final protective film is removed and extending to a pixel region, and

wherein the final protective film is not interposed between the pixel electrode and the transparent substrate in a pixel region corresponding to at least one color of the plurality of colors.

[Claim 24] A liquid crystal display apparatus comprising:

a TFT substrate having a thin film transistor;

a CF substrate having a plurality of color filter having a plurality colors;

a liquid crystal inserted between the TFT and CF substrates,

wherein the TFT substrate comprises:

a transparent substrate;

the thin film transistor formed on the transparent substrate;

a final insulating protective film for coating at least the thin film transistor; and

a pixel electrode electrically connected to the thin film transistor at a portion where the final protective film is removed and extending to a pixel region, and

wherein a thickness of the final protective film interposed between the pixel electrode and the transparent substrate is smaller than that of the final protective film on the thin film transistor.

[Claim 25] A method of manufacturing a liquid crystal display apparatus, comprising steps of:

forming a plurality of gate bus lines on a substrate;

forming a first insulating film on an entire upper surface of the substrate to

coat the gate bus lines;

forming a plurality of data bus lines on the first insulating film and thin film transistors on respective pixel regions;

forming a second insulating film on the entire upper surface of the substrate to coat the thin film transistor;

selectively etching the second insulating film on the thin film transistor to expose an electrode of the thin film transistor and etching the second insulating film on the pixel region;

forming a conductive film on the entire upper surface of the substrate and pattering the conductive film, thereby forming pixel electrodes on the respective pixel regions.

[Claim 26] A liquid crystal display apparatus constructed by attaching a first substrate having a black matrix formed by stacking a plurality of color filters having different colors to a second substrate with a sealing member and injecting a liquid crystal between the first and second substrates through a liquid crystal injection inlet, the liquid crystal display apparatus comprising:

a pillar formed by stacking a plurality of the color filters at the liquid crystal injection inlet of the first substrate; and

a gap sustaining spacer formed on the pillar and having a distal end portion being in contact with the second substrate.

[Claim 27] The liquid crystal display apparatus according to Claim 26, further comprising a domain control protrusion formed on the color filters of pixel portions and made of the same material as the gap sustaining spacer.

[Claim 28] A method of manufacturing a liquid crystal display apparatus, comprising steps of:

forming a color filter having at least one color of red, green, and blue color filters on an pixel portion of a first substrate, forming a black matrix by stacking two of the color filters on a light shielding region outside an inter-pixel region and a display region, and forming a pillar by stacking at least two of the red, green, and blue color filters at a portion to be a liquid crystal injection inlet;

forming a domain control protrusion on the color filter of the pixel portion and forming a first gap sustaining space by stacking the color filters on the pillar;

attaching the first and second substrates by contacting a distal end portion of the first gap sustaining spacer to the second substrate;

injecting a liquid crystal between the first and second substrates through the liquid crystal injection inlet; and

molding the liquid crystal injection inlet.

[Claim 29] A method of manufacturing a liquid crystal display apparatus, comprising steps of:

forming a color filter having at least one color of red, green, and blue color filters on an pixel portion of a substrate, forming a black matrix by stacking two of the color filters on a light shielding region outside an inter-pixel region and a display region, and forming a pillar by stacking at least two of the red, green, and blue color filters at a portion to be a liquid crystal injection inlet; and

forming a domain control protrusion on the color filter of the pixel portion and forming a first gap sustaining space by stacking the color filters on the pillar.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a liquid crystal display apparatus having a

high display quality and a method of manufacturing the same.

[0002]

[Description of the Related Art]

In an active matrix liquid crystal display apparatus, switching devices for blocking a signal in an off state during a non-selected mode is formed on each pixel to prevent cross talk, so that the active matrix liquid crystal display apparatus has a good display characteristic in comparison to a simple matrix liquid crystal display apparatus. In particular, in a liquid crystal display apparatus using thin film transistors (TFT) as a switching device, since the driving capability of the TFTs is high, the liquid crystal display apparatus has a good display characteristic almost similar to that of the CRT (cathode ray tube).

[0003]

In general, a liquid crystal display apparatus has a structure where a liquid crystal is inserted between two transparent substrates. On one surface of one of the two facing transparent substrates, a common electrode, color filters, and an alignment film are formed, and on one surface of the other of the two facing transparent substrates, TFTs, pixel electrodes, and an alignment film are formed. In addition, on the opposite surfaces of the facing surfaces of the transparent substrates, respective polarizing plates are attached. In a TN (twisted nematic) liquid crystal display apparatus, in a case where the polarization axes of the two polarizing plates are disposed perpendicular to each other, when an electric field is not applied, light is passed, and when the electric field is applied, the light is shied, so that a normal whit mode is obtained. On the other hand, in a case where the polarization axes of the polarizing plates are disposed parallel to each other, a normal black mode is obtained. Now, the substrate on which TFTs and

pixel electrodes are formed is referred to as a TFT substrate, and the substrate on which the common electrode and the color filters are formed is referred to as a CF substrate.

[0004]

Recently, a high quality liquid crystal display apparatus is greatly required, and particularly, improvement of viewing characteristics and display quality are greatly required. In order to satisfy these requirements, a vertical aligned (VA) liquid crystal display apparatus, particularly, a multi-domain vertical aligned (MVA) liquid crystal display apparatus have been considered to be a good liquid crystal display apparatus. FIG. 73 is a cross sectional view showing an example of a conventional MVA liquid crystal display apparatus.

[0005]

The liquid crystal display apparatus comprises a TFT substrate 510, a CF substrate 520, and a vertically aligned liquid crystal inserted between the substrates 510 and 520. In addition, under the TFT substrate 510 and on the CF substrate 520, polarizing plates (not shown) are disposed, wherein the polarization axes are perpendicular to each other. The TFT substrate 510 is constructed as follows. On a transparent glass substrate 511, a plurality of pixel electrodes 516 in matrix, TFTs connected to the pixel electrodes 516, data bus lines for supplying image data to the pixel electrode through the TFTs, and gate bus lines are formed. The pixel electrodes 516 are made of a transparent conductive material such as ITO (indium tin oxide).

[0006]

In addtoin, on the pixel electrodes 516, a domain control protrusion 517 is formed. In addition, on surfaces of the pixel electrodes 516 and the protrusion

571, an alignment film (not shown) made of polyimide or the like are coated. On the other hand, the CF substrate 520 is constructed as follows. On a lower surface of a glass substrate 521, a black matrix made of Cr or the like are formed to shield the inter-pixel regions. In addition, on a lower surface of the glass substrate 521, one of the red (R), green (G), and blue (B) color filters 523 are formed for each pixel. Under the color filters 523, a common electrode 524 made of a transparent conductive material such as ITO is formed. Under the common electrode 524, a domain control protrusion 525 is formed. In addition, on surfaces of the common electrode 524 and the protrusions 525, an alignment film (not shown) made of polyimide or the like is coated.

[0007]

In the liquid crystal display apparatus, when a voltage is not applied, the liquid crystal molecules are aligned in the direction perpendicular to the alignment film. In this case, the light incident on the lower side of the TFT substrate 510 through the polarizing plate is shield by the polarizing plate disposed on the CF substrate 520, so that a black display is obtained. On the other hand, when a sufficient voltage is applied between the pixel electrode 516 and the common electrode 524, as shown in FIG. 74, the liquid crystal molecules 529a are aligned in the direction perpendicular to the electric field. In this case, the tilt angles of the liquid crystal molecules 529 in the both sides are different from each other, so that the so-called alignment portion (multi-domain) is obtained. In this state, the light incident on the lower side of the TFT 510 through the polarizing plate is passed, so that a bright display is obtained. By controlling the applying voltage for each pixel, a desired image can be displayed in the liquid crystal display apparatus. In addition, since light leakage in the slanting direction of the alignment portion are

suppressed, so that the viewing characteristic is improved.

[0008]

In addition, in the above example, although the protrusions are provided on both of the TFT substrate 510 and the CF substrate 520, as shown in FIG. 75. However, the slits 561a may be formed on electrodes (pixel electrodes of the TFT substrate in FIG. 75) of one substrate, so that the same effect can be obtained. In general, in the conventional liquid crystal display apparatus, in order to maintain the interval (cell gap) between the pixel electrode and the common electrode in a constant value, square or bar shaped spacer (having a uniform diameter) are used. The spacer is made of a resin, a ceramic, or the like. When the spacers are in contact with the TFT substrate 510 and the CF substrate 520, the spacers are dispersed on one substrate. Therefore, the cell gap between the pixel electrode and the common electrode is defined by a diameter of the spacers.

[0009]

In addition, in Japanese Patent Application Nos. 10-68955 and 11-264968, a pillar shaped member formed by using photoresist is used as a spacer in order to prevent defects such as non-uniformity of cell gap caused by the square or bar shaped spacers.

[0010]

[Problems to be Solved by the Invention]

In the conventional liquid crystal display apparatus, there is a need to improve a display quality. An object of the present invention is to a liquid crystal display apparatus, a method of manufacturing the same, a color filter substrate, and a method of manufacturing the same capable of obtaining a good display quality of a liquid crystal display apparatus in comparison to a conventional liquid

crystal display apparatus.

[0011]

[Means for Solving the Problems]

In a liquid crystal display apparatus according to Claim 1, there is provided a vertically aligned liquid crystal display apparatus where a vertically aligned liquid crystal is inserted into a pair of substrates, comprising: a cell gap adjustment spacer formed on at least one of the two substrates to maintain the cell gap in a constant value; and a domain control protrusion formed on the substrate where the spacer is formed and made of the same material as that of the spacer, wherein a height of the domain control protrusion is larger than that of the spacer.

[0012]

In the present invention, a cell gap adjustment spacer for maintaining the cell gap in a constant value, the height of the domain control protrusion is larger than that of the spacer, and the spacer and the protrusion are made of the same material by using the same process. For example, in Claim 2 and 3, a photoresist film is formed on a substrate, an exposure process is preformed on the spacer formation region and the protrusion formation region with different light amounts, and a developing process is performed. In this case, since the exposure amounts for the spacer formation region and the protrusion formation region are different from each other, the spacer and the protrusion having different thicknesses can be simultaneously formed.

[0013]

As disclosed in Claims 5 and 6, the width of the spacer formation pattern is formed to be smaller than the width of the protrusion formation pattern, and after the exposure process, the resist (resin) is reflowed by performing a post-baking

process, the spacer and the protrusion having a smaller height than that of the spacer can be simultaneously formed. In a liquid crystal display apparatus according to Claim 8, the liquid crystal display apparatus having a black matrix is formed by stacking at least two color filters on a substrate, and the edges of at least two of red, green, and blue pixels is defined by an edge of an upper color filter.

[0014]

In general, a color filter of a liquid crystal display apparatus is formed by using a photoresist made of a pigment dispersive resin. In this case, in an exposure process for patterning the color filter, the edge position of the color filter may be changed due to the reflected light from the grooves in the stage of the exposure apparatus. In case of a general liquid crystal display apparatus where the black matrix is made of a metal film or a black resin, the edge of the pixel is defined by the edge of the black matrix. However, in case of a liquid crystal display apparatus where the black matrix is constructed by stacking two or more color filters, the edge position of the pixel is changed due to change in the edge position of the color filter due to the reflected light from the stage of the exposure apparatus, so that display defect may occur.

[0015]

In this case, as described above, by defining the edges of any two or more pixels of the red, green, and blue pixels by the edge of the upper layered (second or third layered) color filters on the substrate, the affect of the reflected light from the stage of the exposure apparatus can be reduced. In a case where the black matrix is constructed by stacking two or more color filters, the edge of the pixel is defined by the first layer color filter (in general, a blue color filter). However, the

first layered color filter is easily affected by the reflected light from the stage of the exposure apparatus, so that the change of the edge position can easily occur.

[0016]

However, if the edge of the pixel is defined by the second or third layered color filter, the reflected light from the stage is absorbed by the first layered color filter, so that the change of the edge position cannot easily occur. In some production situation where an edge of a single color filter is defined by the first layered color filter, a combination of color filter having a smaller OD value (optical density) of the black matrix in vicinity of the corresponding pixel (that is, a stack of red and green color filters or a stack of green and blue color filters) is preferable. In addition, the OD value is defined as, OD value = -log (emitting intensity/ incident intensity).

[0017]

In addition, it is preferable that the substrate is made of an acryl resin plate having a high UV absorbing capability or a film formed by coating the acryl resin plate having a high UV absorbing capability on a glass substrate. By doing so, the display blots caused by the reflected light from the stage of the exposure apparatus can be further reduced. In addition, a material for easily absorbing the UV light (for example, HALS (Hindered Amine Light Stabilizer)) may be added to the first or second layered color filter,

[0018]

In a liquid crystal display apparatus according to Claim 12, the first spacer and the second spacer having a lower height that the first spacer are formed, and in a normal state, the cell gap is defined by the first spacer. When a low pressure is exerted on the liquid crystal display apparatus, the pressure is exerted on only

the first spacer, so that the first spacer is elastically deformed. Since the first spacer is elastically deformed depending on thermal expansion or contraction of the liquid crystal due to temperature, the cell gap changes, so that foams generated in the liquid crystal display apparatus or the separation of the spacers from the substrate can be prevented.

[0019]

In a case where an excessive pressure is exerted, the second spacer as well as the first spacer is in contract with to another substrate, the pressure can be distributed over a wide region. By doing so, defects such as a plastic deformation of the spacers or a short-circuit between the pixel electrode and common electrode due to the excessive pressure can be avoided. The first and second spacers are preferably formed with materials having different pressing displacements. For example, the first spacer is formed with a material having a large pressing displacement (a high elasticity), and the second spacer is formed with a material having a small pressing displacement (a low elasticity), so that the effect can further improve.

[0020]

In addition, although the cell gap adjusting spacer has a structure constructed by stacking a plurality films having different pressing displacements, the same effect can be obtained. The first spacers and the second spacers may be formed by using a photoresist film, for example. In this case, the first spacers may be constructed with a thick photoresist film, and the second spacer is constructed with a thin photoresist film, so that the spacers having different heights can be formed.

[0021]

In addition, in a vertically aligned liquid crystal display apparatus, although a domain control protrusion may be formed on a substrate, the spacer having different heights can be formed by using a photoresist film used to form the protrusion. Namely, in a case where the protrusion is formed by using the first photoresist film, the first photoresist film is remained in a region for forming the spacer (first spacer). After that, on the entire upper surface of the substrate, the second photoresist film is formed, the second photoresist film is remained in the first spacer formation portion and a portion for forming a small height spacer (second spacer formation portion), and the second photoresist film in the other portions are removed. By doing so, two types of spacers having different heights are formed with a height difference corresponding to the thickness of the first photoresist film.

[0022]

In addition, when color filters is formed, the color filter is formed in a portion for forming a large height spacer, and the color filter is not formed in a portion for forming a small height spacer, so that a step difference is prepared therebetween. After that, on the entire surface of the substrate, a resist film is formed, a spacer formation portion is remained, and resist films in the other portions are removed. By doing so, two types of spacers having different heights are formed with a height difference corresponding to the thickness of the color filter.

[0023]

In a liquid crystal display apparatus according to Claim 21, if a spacer distribution density is n (numbers/cm^2); if a displacement amount generated by exerting a force of 9.8/n (N) on one spacer is x; if an average interval between the substrates is d; if a liquid crystal density at a temperature of 60 □ is q_{60} (g/cm^3);

and if a liquid crystal density at a temperature of - 20 □ is q_{-20} (g/cm^3), the following equation is satisfied:

[0024]

$x/d > (1/q_{60} - 1/q_{-20})/(1/q_{60})$

The liquid crystal inserted in the liquid crystal display apparatus is expanded or contracted depending on a temperature. If the cell gap adjusting spacer has no elasticity, when the liquid crystal is expanded, the distal end portion of the spacer is separated from the substrate, so that deviation of the cell gap occurs. Therefore, display blots occur. In addition, when the liquid crystal is contacted, foams are generated due to the decrease in the pressure of the liquid crystal, so that the display quality may greatly deteriorate. Therefore, the spacer must has such an elasticity that the spacer can cope with the expansion or contraction of the liquid crystal due to the change in the temperature.

[0025]

The inventors found out from various experiments that, by selecting a material and density of a spacer to satisfy the aforementioned equation (1), the display defects caused by the expansion or contraction of the liquid crystal can be prevented. When the temperature is low, a viscosity of the liquid crystal is too high, or a phase transition is generated, so that the liquid crystal density cannot be defined. At a temperature of 20 □, in a case where the liquid crystal density q_{20} can be defined, the material and density of the liquid crystal may be selected to satisfy the following equation (2):

[0026]

$x/d > 2^* (1/q_{60} - 1/q_{20})/(1/q_{60})$

A liquid crystal display apparatus according to Claim 23 comprises: a TFT

substrate having a thin film transistor; a CF substrate having a plurality of color filter having a plurality colors; a liquid crystal inserted between the TFT and CF substrates, wherein the TFT substrate comprises: a transparent substrate; the thin film transistor formed on the transparent substrate; a final insulating protective film for coating at least the thin film transistor; and a pixel electrode electrically connected to the thin film transistor at a portion where the final protective film is removed and extending to a pixel region, and wherein the final protective film is not interposed between the pixel electrode and the transparent substrate in a pixel region corresponding to at least one color of the plurality of colors.

[0027]

In the present invention, a final protective film is not interposed between the pixel electrode and the transparent substrate. By doing so, an interval (cell gap) between the pixel electrode and the common electrode can increase by the thickness of the final protective film. Therefore, although the height of the spacer is low, a predetermined cell gap can be maintained. In addition, for example, in only one of a plurality of color pixel regions, the final protective film may not interposed between the pixel electrode and the transparent substrate, and in the other regions, the final protective film may be interposed between the pixel electrode and the transparent substrate. By doing so, the so-called multi cell gap where different cell gaps are provided to respective colors can be implemented.

[0028]

A liquid crystal display apparatus according to Claim 24, a thickness of the final protective film interposed between the pixel electrode and the transparent substrate is smaller than that of the final protective film on the thin film transistor. In this case, the same effect can be obtained. In addition, by adjusting the

thickness of the final protective films, the cell gaps can be optimized for respective colors. By doing so, the display quality can improve.

[0029]

In a method of manufacturing a liquid crystal display apparatus, after a first insulating film, a thin film transistor, and a second insulating film are formed on a substrate, a contact hole is formed on the second insulating film, and at the same time, the second insulating film, or the second insulating film and the first insulating film on the pixel region are etched. By the etching process, the thicknesses of the insulating films (first insulating film and the second insulating film) on the pixel region are thin, and the insulating film is removed, so that the cell gap can increase. In addition, by controlling the etching amount of the second insulating film or the second insulating film and the first insulating film for respective pixel colors, the cell gap can be optimized for respective colors.

[0030]

In this case, the second insulating film is formed in a thick one by using a resin or the like, the second insulating film remaining on the thin film transistor is used as a space r(cell gap adjusting spacer), so that the production process can be simplified. In a liquid crystal display apparatus according to Claim 26, which constructed by attaching a first substrate having a black matrix formed by stacking a plurality of color filters having different colors to a second substrate with a sealing member and injecting a liquid crystal between the first and second substrates through a liquid crystal injection inlet, the liquid crystal display apparatus comprises: a pillar formed by stacking a plurality of the color filters at the liquid crystal injection inlet of the first substrate; and a gap sustaining spacer formed on the pillar and having a distal end portion being in contact with the

second substrate.

[0031]

In a liquid crystal display apparatus where the black matrix is constructed by stacking two or more color filters, the thickness of the black matrix is thickened, so that the interval (gap) between substrate is narrowed. For the reason, the liquid crystal injection time must increase. In addition, in a case where the cell gap adjusting spacer is formed by using a photoresist, if the gap sustaining spacer is not provided to outside of the display region, the interval between the substrates is not uniform. Therefore, the deviation of the liquid crystal injection time increases, so that there occur defects such as foams generated due to insufficient injection or cell gap increase due to excessive injection.

[002=32]

Therefore, in the present invention, in a portion to be the liquid crystal injection inlet, a spacer for maintaining the interval in a constant value is formed. By means of the spacer, the interval of the liquid crystal injection inlet can be maintained in a constant value, so that the deviation in the liquid crystal injection time can be avoided. As a result, the defects such as the foam generation the cell gap increase can be prevented. In a method of manufacturing a liquid crystal display apparatus according to Claim 29, the method comprises steps of: forming a color filter having at least one color of red, green, and blue color filters on an pixel portion of a first substrate, forming a black matrix by stacking two of the color filters on a light shielding region outside an inter-pixel region and a display region, and forming a pillar by stacking at least two of the red, green, and blue color filters at a portion to be a liquid crystal injection inlet; forming a domain control

protrusion on the color filter of the pixel portion and forming a first gap sustaining space by stacking the color filters on the pillar; attaching the first and second substrates by contacting a distal end portion of the first gap sustaining spacer to the second substrate;

injecting a liquid crystal between the first and second substrates through the liquid crystal injection inlet; and molding the liquid crystal injection inlet.

[0033]

Like this, in a proton to be the liquid crystal injection inlet, a pillar is formed by stacking at least two of the red, green, and blue color filters, and the a gap sustaining spacer is formed thereon at the same time of forming a domain control protrusion in the display region, so that the interval of the liquid crystal injection inlet can be maintained at a constant value. In addition, increase in the number of production processes can be avoided.

[0034]

It is preferable that the height (height from the surface of the substrate) of the first gap sustaining space of the liquid crystal injection inlet is larger than the height (height form the surface of the substrate) of the cell gap adjusting spacer in the display region. By doing so, the gap of liquid crystal injection inlet portion increase, so that the liquid crystal injection time can be shortened. Although the liquid crystal injection inlet is generally molded by using a UV cured resin, the UV cured resin has a characteristic that it is contracted during the curing process. Therefore, if the height of the first gap sustaining spacer of the liquid crystal injection inlet is set to be larger than that of the cell gap adjusting spacer in the display region, the gap between the first and second substrate of the liquid crystal injection inlet portion is narrowed during the curing process, the cell gap can be

maintained at a constant value over the entire liquid crystal panel.

[0035]

[Embodiments]

Now, embodiments of the present invention will be described with reference to the accompanying drawings.

(First Embodiment)

FIG. 1 is a cross sectional view of a liquid crystal display apparatus according to a first embodiment of the present invention. FIG. 2 is an enlarged view of a spacer formation portion in the liquid crystal display apparatus. FIG. 3 is a plan view of a TFT substrate of the liquid crystal display apparatus. FIG. 4 is a plan view of a CF substrate of the liquid crystal display apparatus. In addition, FIGS. 1 and 2 show cross sections taken align a line indicated by an arrow A of FIG. 4.

[0036]

The liquid crystal display apparatus has a structure where a vertically aligned liquid crystal (a negative type liquid crystal) 29 is inserted between a TFT substrate 10 and a CF substrate 20. Polarizing plates (not shown) are disposed on a lower portion of the TFT substrate 10 and an upper portion of the CF substrate 20. Polarization axes of the polarizing plates are perpendicular to each other. The TFT substrate 10 comprises a substrate 11 (hereinafter, referred to as a glass substrate) made of a transparent material such as glass and plastic, pixel electrodes 16a formed on an upper surface of the glass substrate 11, insulating films 13 and 15, and an alignment film 17. As shown in FIG. 3, on the lower portion of the glass substrate 11, a plurality of gate bus lines 12a are disposed parallel to each other. Between the gate bus lines 12a, auxiliary capacitance bus

lines 12b are formed. The gate bus lines 12a and the auxiliary capacitance bus lines 12b are coated with the insulating film 13 (a gate insulating film) formed on the upper surface of the glass substrate 11 (see FIG. 2). Over the insulating film 13, a silicon film 18a is selectively formed to be an activation layer of TFTs 18. The silicon film 18a is made of an amorphous silicon or a polysilicon.

[0037]

The silicon film 18a is covered with an insulating film (not shown). A plurality of data bus lines 14a, source electrodes 18b and drain electrodes 18c of the TFTs 18 are formed on the silicon film 18a. The data bus lines 14a and the drain electrodes 18c are disposed perpendicular to each other. In addition, rectangular regions partitioned by the gate bus lines 12a and the data bus lines 14a are regions to be pixels.

[0038]

The data bus lines 14a, the source electrodes 18b, and the drain electrodes 18c are covered with an insulating film 15 (a final protective film). On the insulating film 15, each of pixel electrodes 16a made of ITO are formed corresponding to each pixel. The pixel electrodes 16a are electrically connected to the source electrodes 18b through contact holes formed on the insulating film 15.

[0037]

As shown in FIG. 3, in the pixel electrodes 16a, slits 16a are formed along zigzag-shaped dash-dot lines. On the entire upper surface of the glass substrate 11, a vertical alignment film 17 is formed. The surface of the pixel electrodes 16a are covered with the vertical alignment film 17. On the other hand, the CF substrate 20 comprises a glass substrate 21, a black matrix 22 formed on a lower

surface of the glass substrate 21, color filters 23R, 23G, and 23B, a common electrode 24, protrusions 25b, and a vertical alignment film 26. As shown in FIG. 2, on the lower surface of the glass substrate 21, the black matrix 22 made of Cr thin film is formed. The black matrix 22, as shown in FIG. 24, are formed to cover the gate bus lines 12a, the data bus lines 14a, the auxiliary capacitance bus lines 12b, and the TFTs 18 of the TFT substrate 10.

[0040]

On the lower surface of the glass substrate 21, the red (R), green (G), and blue (B) color filters 23R, 23G, and 23B are formed. The color filters 23R, 23G, and 23B are disposed at position facing the pixel electrodes 16a of the TFT substrate 10. One pixel electrode 16a corresponds to one of the color filters 23R, 23G, and 23B.

[0041]

Under the black matrix 22 and the color filters 23R, 23G, and 23B, the common electrode 24 made of ITO are formed. In addition, under the common electrode 24, cell gap adjusting spacers 25a and domain control protrusions 25b are formed. The domain control protrusions 25b, as shown in FIG. 4, are formed in a zigzag shape, and the cell gap adjusting spacers 25a are disposed in a vicinity of intersections of the gate bus lines 12a and the data bus lines 14a. Heights (a height from a surface of the common electrode 24) of the cell gap adjusting spacers 25a are about 4.0 μm and made of an insulating resin. In addition, heights (a height from the surface of the of the domain control protrusions 25b) of the domain control protrusions 25b are about 1.5 μm. As described later, the domain control protrusions 25b and the cell gap adjusting spacers 25a are formed at the same time with the same material. In addition, as

shown in FIG. 4, the dash-dot line indicates positions of the slits 16b formed at the pixel electrode 16a of the TFT substrate 10. Under the common electrode 24, the vertical alignment film 26 is formed, and surfaces of the cell gap adjusting spacers 25a and the domain control protrusions 25b are covered with the vertical alignment film 26.

[0042]

In the embodiment, the domain control protrusions 25b of the CF substrate 20 are formed with a height of about 1.5 μm, and the cell gap adjusting spacers 25a are formed with a height of about 4.0 μm. As shown in FIG. 1, the distal end portions of the cell gap adjusting spacers 25a are in contact with the TFT substrate 10 to sustain the cell gap uniformly. For the reason, in the embodiment, square or bar shaped spacers required conventionally are not needed. Therefore, a process for dispersing spacers can be reduced. In addition, the interval between the pixel electrode 16a of the TFT substrate 10 and the common electrode 24 of the CF substrate 20 can be maintained in a constant value due to the cell gap adjusting spacers 25a formed at predetermined positions, so that it is possible to completely preventing short-circuit of the pixel electrodes 16a and the common electrode 24. In addition, in a conventional liquid crystal display apparatus using the square or bar shaped spacers, since the liquid crystal molecules in vicinity of the spacers are aligned along the surface of the spacer, the alignment is in a disorder, so that display defect occurs. However, in the embodiment, since the square or cylindrical spacers are not used, it is possible to obtain a good display quality.

[0043]

In addition, in the embodiment, since the alignment portion are obtained by

the slit 16b formed at the pixel electrodes 16a of the TFT substrate 10 the protrusions 25b formed at the CF substrate 20, it is possible to obtain a good viewing characteristic and a contrast characteristic. In addition, in the embodiment, the cell gap can be maintained in a constant value by the spacers 25a formed at the CF substrate 20. The spacers 25a are fixed on the common electrode 24, so that the cell gap is not changed due to vibration or impact. Therefore, it is possible to prevent deterioration in the display quality caused by spacer movement.

[0044]

Now, a method of manufacturing a liquid crystal display apparatus according to the first embodiment will be described. FIGS. 5 to 9 shows views of a series of processes of the method of manufacturing the CF substrate of the liquid crystal display apparatus according o the embodiment. Firstly, as shown in FIG. 5(a), a low reflectance Cr film is formed on one surface (an upper surface in the figure) of a transparent substrate 21; and a novolak positive type photoresist are coated thereon. Next, the photoresist are selectively exposed by using a predetermined mask, and a developing process is performed, thereby remaining a Cr film on only a predetermined region. By doing so, a black matrix 22 made of the Cr film is formed.

[0045]

Next, a photosensitive pigment dispersive type red resist is coated on the entire upper surface of the substrate 21, and an exposure process and a developing process are performed, thereby forming a red color filter 23R having a thickness of about 1.5 μm on a red pixel portion as shown in FIG. 59b). Next, a photosensitive pigment dispersive type green resist is coated on the entire upper

surface of the substrate 21, and an exposure process and a developing process are performed, thereby forming a green color filter. 23G having a thickness of about 1.5 μm on a green pixel portion as shown in FIG. 5(b).

[0046]

Next, a photosensitive pigment dispersive type blue resist is coated on the entire upper surface of the substrate 21, and an exposure process and a developing process are performed, thereby forming a blue color filter 23B having a thickness of about 1.5 μm on a green pixel portion as shown in FIG. 5(c). Next, as shown in FIG. 6(b), on the entire upper surface of the substrate 21, an ITO film having a thickness of about 0.15 μm are formed, thereby forming a common electrode 24.

[0047]

Next, as shown in FIG. 6(c), by using a spin coating method, a positive type photosensitive novolak resist 25 having a thickness of about 4.0 μm is coated on the common electrode 24, and then, a pre-baking process is performed. Next, as shown in a schematic view of FIG. 7(a), by using a large-sized mask for shielding a spacer formation portion and a protrusion formation portion, the resist 25 is subject to a proximity exposure process. Here, the required exposure amount corresponds to such an amount that the exposed portion of the resist 25 cannot be remained after the developing process. In addition, as shown in FIG. 7(a), the hatched portion of the resist 25 denotes the exposed portion. In addition, in FIG. 7(a), the black matrix and the color filters 23R, 23G, and 23B are not shown.

[0048]

Next, as shown in a schematic view of FIG. 7(b), by using a large-sized mask for shielding the spacer formation portion, the resist 25 is subject to a

proximity exposure process. Here, the required exposure amount corresponds to such an amount that the exposed portion (the protrusion formation portion) of the resist 25 can be remained in a thickness of 1.5 μm after the developing process. Next, by using TMAH (tetra methyl ammonium hydroxide) alkali developing solution having a concentration of 2.3%, the resist 25 is subject to a shower-developing process. By doing so, as shown in FIG. 8(a), the spacers 25a and the protrusions 25b having different heights are simultaneously formed from the resist 25. After that, the substrate 21 is inserted in a clean oven, and then, a post-baking is performed at a temperature of 200 □ in 1 hour. By doing so, the resist resin is softened, so that the shapes of the spacers 25a and the protrusions 25b slightly change as shown in FIG. 8(b). A cross section of the CF substrate 20 after the post-baking process is shown in FIG. 9.

[0049]

Next, an alignment film 26 (see FIG. 2) is formed on the entire upper surface of the substrate 21, and surfaces of the common electrode 24, the spacers 25a, and the protrusions 25b are covered with the alignment film 26. By doing so, the CF substrate is completed. On the other hand, the TFT substrate 10 is formed by using a well-known method. On a glass substrate 11, gate bus lines 12a and storage capacitance bus lines 12b are formed, and an insulating film 13 (a gate insulating film) is formed thereon. Next, on the insulating film 13, a silicon film 18a to be an activation layer of the TFTs 18 are formed, and data bus lines 14a, source electrodes 18b and drain electrodes 18c of the TFTs 18 are formed (see FIGS. 2 and 3).

[0050]

Next, one the entire upper surface of the glass substrate 11, an insulating

film 15 (a final protective film) are formed, and pixel electrodes 16a made of ITO are formed thereon. Here, in the pixel electrodes 16a, as shown in FIG. 3, slits 16b are formed in a zigzag shape. Next, on the entire surface of the substrate 11, an alignment film 17 is formed, and the surfaces of the pixel electrodes 16a are covered with the alignment film 17. By doing so, the TFT substrate 10 is completed.

[0015]

As shown in FIGS. 1 and 2, the TFT substrate 10 and the CF substrate 20 are disposed to face the surfaces on which the alignment films 17 and 26 are formed, and a distal end portion of the spacers 25a are disposed to be in contact with inter-pixel regions (intersections of the gate bus lines and the data bus lines). Next, a sealing member is coated on outer portion of a display region of at least one of the TFT substrate 10 and the CF substrate 20, and the TFT substrate 10 and the CF substrate 20 are attached to each other with the sealing member. Next, a liquid crystal is inserted into a space between the TFT substrate 10 and the CF substrate 20, and a liquid crystal injection inlet is molded with a resin. By doing so, the liquid crystal display apparatus is completed.

[0052]

In the embodiment, as shown in FIG. 7, since the photoresist 25 is subject to an exposure process and a developing process to form the spacers 25a, the heights of the spacers 25a are uniform, and the spacers 25a can be formed at predetermined positions. Therefore, in the embodiment, in comparison to a conventional method where square or bar shaped spacers are dispersed, although the domain control protrusions 25b are provided, the cell gap can be maintained in a constant value over the entire display region. For the reason, in

comparison to the conventional method, it is possible to improve a display quality. In addition, in the embodiment, since the common electrode 24 is disposed closer to the substrate 21 than to the spacers 25a, the interval between the common electrode 24 ad the pixel electrodes 16a increases, so that a possibility of short-circuit may decreases.

[0053]

In addition, in the embodiment, by performing the exposure process in twice by using the two types of masks 27 and 28, the spacers 25a and the protrusions 25b having different heights are simultaneously formed, so that the number of production processes can be reduced. By doing so, it is possible to manufacture a liquid crystal display apparatus having a good viewing characteristic. In addition, in a case where the spacers 25a and the protrusions 25b are formed by using a positive type resist, it is preferable that a positive resist having a long exposure time (required exposure amount) or a large molecular weight is used in order to reduce film loss with respect to an exposure energy (exposure time) in a resist developing process. In addition, it is also effective to increase a pre-baking temperature or decreases a concentration of a developing solution in order to reduce film loss (a rate of loss in a resist film thickness per a unit time) in the exposure developing process.

[0054]

In addition, in the above example, as the material for forming the spacers 25a and the protrusions 25b, the novolak resist is used, but not limited thereto. As the material for forming the spacers 25a and the protrusions 25b, an acryl resin resist or an epoxy resin resist may be used. In addition, instead of the positive type resist, a negative type photosensitive resin may be used.

[0055]

In addition, in the above example, although a case where the spacers 25a and the protrusions 25b are formed on the CF substrate 20, the spacers and the protrusions may be formed on the TFT substrate. In this case, slits or protrusions are formed on the common electrode 24 of the CF substrate 20.

(Second Embodiment)

Now, a second embodiment of the present invention will be described. The difference of the second embodiment from the first embodiment is that a method of forming the spacers 25a and the protrusions 25b of the CF substrate 20 is different. The other constructions are basically similar to those of the first embodiment, and thus, description of the same constructions will be omitted.

[0056]

FIGS. 10 to 14 show a method of manufacturing a CF substrate in a liquid crystal display apparatus according to a second embodiment. FIG. 10 shows a positional relation between a light shielding pattern of a mask and a pixel. FIG. 11 shows after-formation spacer and protrusion patterns. FIG. 12(a) is a cross sectional view of a spacer formation portion (taken along line B-B). FIG. 12(b) is a cross sectional view of a protrusion formation portion (taken along line C-C). FIG. 13 is a cross sectional view showing a manufacturing method in the position of the line C-C of FIG. 11. FIG. 14 is cross sectional view showing a manufacturing method in the position of the line B-B of FIG. 11. In FIGS. 11 to 14, the same reference numerals denote the same components as those of the first embodiment.

[0057]

Firstly, as shown in FIGS. 13 and 14, similar to the first embodiment, a

black matrix 22, color filters 23R, 23G, and 23B, and common electrode 24 are formed on a glass substrate 21. Next, by using a spin coating method, a positive type photosensitive novolak resist 25 having a thickness of about 4.0 μm is coated on the common electrode 24, and then, a pre-baking process is performed.

[0058]

Next, as shown in FIG. 10(a), by using a mask 31 on which a protrusion shielding pattern (a zigzag pattern) 31a and a spacer shielding pattern (a rectangular pattern) 31b are formed, the resist 25 is subject to a proximity exposure process. In the mask 31, the three RGB pixels arrayed in a horizontal direction is treated as one unit. In a region corresponding to pixel regions in two units among pixel regions in three units arrayed in the horizontal direction, six protrusion formation shielding patterns 31a having the same shape are formed. And in a region (a region indicated by a dot line in FIG. 10) corresponding to pixel regions in the remaining one unit, the protrusion formation shielding pattern 31a is not formed. In addition, in a ratio of one spacer shielding pattern 31b to every three pixels, the spacer shielding patterns are disposed to a region corresponding to intersection regions of the data bus lines and the gate bus lines.

[0059]

Firstly, as shown in FIGS. 10(a), 13(a), and 14(a), by positioning the mask 31, a fist exposure process is formed. Here, the exposure amount is 1/3 of a normal exposure amount with respect to a resist film thickness of 4 μm. In FIGS. 13 and 14, the hatched portions denote exposed portions. In addition, the normal exposure amount means an exposure amount corresponding to a case where an exposed portion is not remained after a developing process.

[0060]

Next, as shown in FIGS. 10(b), 13(b), and 14(b), the mask 31 is shifted by three pixels in a predetermined direction (a direction indicated by an arrow in FIG. 10(b)), and then, a second exposure process is performed with 1/3 of the normal exposure amount. In this case, all the spacer formation portions are shielded by the shielding patterns 31b of the mask 31. In addition, as shown in FIGS. 10(c), 13(c), and 14(c), the mask 31 is shifted by three pixels in a predetermined direction (a direction indicated by an arrow in FIG. 10(c)), and then, a third exposure process is performed with 1/3 of the normal exposure amount. In this case, all the spacer formation portions are also shielded by the shielding patterns 31b of the mask 31. In addition, in all the protrusion formation portions, 1/3 of the normal exposure amount is illuminated.

[0061]

Next, a developing process is performed on the resist 25. Here, the protrusion formation regions are exposed with 1/3 of the normal exposure amount, and the spacer formation regions are not exposed. Therefore, as shown in FIGS. 12(a) and 12(b), there is a difference between after-developing thicknesses (height). By doing so, the spacers 25a and the protrusions 25b having different thicknesses are simultaneously formed on the glass substrate 21. After the developing process, similar to the first embodiment, a post-baking process is performed. After that, an alignment film is formed on the entire upper surface of the glass substrate 21. By doing so, the CF substrate 20 is completed.

[0062]

In the embodiment, the same effect as the first embodiment is obtained. In addition, there is an advantage in that one mask is sufficient to form the spacers 25a and the protrusions 25b. In addition, in the above example, in case of the

thickness of 4.0 μm, the resist having an after-developing film thickness of 1.5 μm corresponding to 1/3 of the normal exposure amount is used. However, for example, in case of a resist having an after-developing film thickness of 1.5 μm corresponding to 1/2 of the normal exposure amount, as shown in FIG. 15, there may be used a mask where the protrusion formation shielding patterns 31a are formed in a regions corresponding pixel regions in one unit among pixel regions in two units and a shielding pattern is not formed in a region corresponding to other pixel regions. In addition, after the first exposure process is performed, the mask may be shifted by three pixels, the second exposure process may be performed, and the developing process may be performed. Like this, in the embodiment, in consideration of the resist characteristics, the mask type and the times of exposure processes may be properly selected.

[0063]

(Third Embodiment)

Now, a third embodiment of the present invention will be described. The difference of the third embodiment from the first embodiment is that a method of forming the spacers 25a and the protrusions 25b of the CF substrate 20 is different. The other constructions are basically similar to those of the first embodiment, and thus, description of the same constructions will be omitted.

[0056]

FIGS. 16 to 18 are schematic views showing a method of manufacturing a CF substrate in a liquid crystal display apparatus according to the third embodiment. FIG. 16 is a schematic cross sectional view of an exposure process. FIG. 17 is a plan view of a protrusion formation pattern. FIG. 18 is a schematic enlarged cross sectional view of protrusion formation region in an exposure

process. In addition, in FIGS. 16 and 18, the black matrix 22, the color filters 23R, 23G, and 23B, and the common electrode 24 formed on the substrate 21 are not shown.

[0065]

Firstly, similar to the first embodiment, a black matrix 22, color filters 23R, 23G, and 23B, and common electrode 24 are formed on a glass substrate 21. Next, by using a spin coating method, a positive type photosensitive novolak resist 25 having a thickness of about 4.0 μm is coated on the common electrode 24, and then, a pre-baking process is performed. Next, as shown in FIG. 16, by using a mask 32 on which shielding patterns having different light transmittance (a light shielding amount) with respect to the spacer formation portions and the protrusion formation portions are formed, the resist 25 is subject to a proximity exposure process. Namely, in the mask 32, a spacer formation patterns for shielding substantially 100% of the light and the protrusion formation patterns for shielding 1/2 ~ 1/10 of the light are formed. For example, both of the spacer formation patterns and the protrusion formation pattern are formed by pattering a Cr film. In the protrusion formation pattern, as shown in FIG. 17, a plurality of small opening portions 32a which is less than a resolution limit are formed. In this case, by adjusting the density of the opening portions and the opening area, it is possible to control the light transmittance.

[0066]

If the resist 25 is exposed by using this mask 23 and a developing process is performed, since the resist 25 is not exposed in the spacer formation portion, the thick resist is remained. On the other hand, in the protrusion formation portion, since the resist is exposed with a smaller exposure amount than the normal

exposure amount, the resist is remained in the substrate 21. However, the thickness of the resist 25 in the protrusion formation patterns is smaller than that in the spacer formation patterns.

[0067]

Like this, by performing the exposure and developing processes at one time, the spacers 25a and the protrusions 25b having different thickness can be simultaneously formed. After that, similar to the first embodiment, a post-baking process is performed. After that, an alignment film is formed on the entire upper surface of the glass substrate 21. By doing so, the CF substrate 20 is completed. In the embodiment, the same effect as the first embodiment is obtained. In addition, there is an advantage in that, since the exposure and developing processes are performed at one time to form the spacers 25a and the protrusions 25b, it is possible to shorten the production time.

[0068]

In addition, in the embodiment, since a pattern having the opening portions 32a are used for the protrusion formation patterns, unevenness is likely to be remained on the surface of the resist (protrusions 25b). However, in the post-baking process performed after the developing process, the resist is softened (reflowed) by heating, the surface can be smoothed. By doing so, it is possible to avoid abnormal alignment of liquid crystal molecules caused by the unevenness of the surface of the protrusions 25b.

[0069]

In addition, in the embodiment, although a pattern having fine opening portions 32a is used as a protrusion formation pattern, as shown in FIG. 19, a protrusion formation pattern 33a made of UV-resistant low-transmittance material

may be formed over or under the mask 33 to adjust the exposure amount for the protrusion formation portions. As a material for the protrusion formation patterns 33a, for example, there may be used a material obtained by mixing a photosensitive acryl resin and a pigment similar to a material for forming a color filter and controlling i-line (wavelength: 365 nm) transmittance as 25%.

[0070]

In this case, the mask 33 is formed as follows. A photosensitive acryl resin containing a pigment is coated on a surface of the mask 33 on which the spacer shielding pattern 33b is formed by etching a Cr film. Next, by using a mask on which a protrusion formation pattern is formed, the photo sensitive acryl resin is exposed to transfer the protrusion formation pattern. After that, by performing exposure, developing, and post-baking processes, the mask 33 having the spacers 25a and the protrusions 25b are formed. By doing so, the mask 33 having the spacer shielding pattern 33b for shielding substantially 100% of the light and the protrusion formation pattern 33a having an i-line transmittance of 25% can be formed.

[0071]

Here, although the transmittance of the protrusion formation pattern 33a is 25%, the transmittance of the protrusion formation pattern 33a may be properly adjusted in accordance with a type of the resist or a height of the protrusions.

(Fourth Embodiment)

Now, a fourth embodiment of the present invention will be described. The difference of the fourth embodiment from the first embodiment is that a method of forming the spacers 25a and the protrusions 25b of the CF substrate 20 is different. The other constructions are basically similar to those of the first

embodiment, and thus, description of the same constructions will be omitted.

[0072]

FIGS. 20 and 21 are views showing a method of manufacturing a CF substrate in a liquid crystal display apparatus according to the fourth embodiment. FIG. 20 s a schematic cross sectional view of an exposure process. FIG. 21 is a schematic enlarged cross sectional view of protrusion formation region. In addition, in FIGS. 20 and 21, the black matrix 22, the color filters 23R, 23G, and 23B, and the common electrode 24 formed on the substrate 21 are not shown.

[0073]

Firstly, similar to the first embodiment, a black matrix 22, color filters 23R, 23G, and 23B, and common electrode 24 are formed on a glass substrate 21. Next, by using a spin coating method, a positive type photosensitive novolak resist 25 having a thickness of about 4.0 μm is coated on the common electrode 24, and then, a pre-baking process is performed. Next, by using a mask 34, a proximity exposure process is performed. In the mask 34, a protrusion formation pattern 34a having a width of 10 μm and a spacer formation pattern having a width of 20 ~ 35 μm are formed.

[0074]

In the embodiment, in order to increase a refraction degree of a refracted light, the proximity gap is adjusted at a value of 150 μm, and the exposure amount is adjusted as .1.5 times of the normal exposure amount. By doing so, in the protrusion formation pattern 34a having a small line width, since the shielding portion is also slightly exposed by the refracted light, the after-developing thickness is smaller than that of non-exposed portion. On the contrary, in the spacer shielding pattern 34b, since the size thereof is larger than that of the

protrusion formation pattern 34a, the influence of the refracted light is lowered. Therefore, in an edge portion of the protrusion formation pattern 34a, although the after-developing thickness is smaller than that of the non-exposed portion, the thickness of a central portion is equal to that of the non-exposed portion. As a result, it is possible to simultaneously form the protrusion having a large height and the spacer having a small height.

[0075]

After that, similar to the first embodiment, a post-baking process is performed. After that, an alignment film is formed on the entire upper surface of the glass substrate 21. By doing so, the CF substrate 20 is completed. In the embodiment, the same effect as the first embodiment is obtained. In addition, there is an advantage in that, since the exposure and developing processes are performed at one time to form the spacers and the protrusions, it is possible to shorten the production time.

[0076]

In addition, the height and width of the protrusion is changed depending on the thickness of the resist 25, the width of the protrusion formation pattern 34, the parallel degree of the light emitting from the proximity exposure apparatus, the proximity gap (an interval between the mask and the resist film), and the exposure amount.

[0077]

(Fifth Embodiment)

Now, a fifth embodiment of the present invention will be described. The difference of the fifth embodiment from the first embodiment is that a method of forming the spacers 25a and the protrusions 25b of the CF substrate 20 is

different. The other constructions are basically similar to those of the first embodiment, and thus, description of the same constructions will be omitted.

[0078]

FIG. 22 is a cross sectional view of a liquid crystal display apparatus according to the fifth embodiment. In the embodiment, three layers of the color filters 23R, 23G, and 23B are stacked on the spacer formation portion, and a cell gap adjusting spacer 41a is formed thereon (a lower portion of FIG. 22). In addition, in the embodiment, a black matrix is formed by stacking the blue color filter 23B and the red color filter 23R. In addition, by forming the black matrix by stacking the color filters 23B and 23R, a Cr film formation process and an etching process are unnecessary, so that it is possible to reduce production time. In addition, in the spacer formation portion, since the three layers of the color filters 23R, 23G, and 23B are stacked, although the height of the spacer 41 is low, it is possible to sustain a predetermined cell gap.

[0079]

In addition, the spacer may be constructed with the stack of the color filters 23R, 23G, and 23B and a domain control protrusion passing thereon. However, since the area of the spacer formation portion is small, and since the novolak resin or the acryl resin generally used as a color filter has a good evenness, even though the thicknesses of the color filters 23R, 23G, and 23B are 1.5 μm and the height of the protrusion is 1.5 μm, the cell gap is less than 4.0 μm.

[0080]

Generally, when the color filter is stacked on the spacer formation portion, until the resin is dried, leveling occur at upper second and third layers of resin portions, the thickness of the second layered color filter is about 70 % of the

thickness of the first layered color filter, and the thickness of the third layered color filter is about 50 % of the thickness of the first layered color filter. If there is no spacer 41a, the cell gap is defined by the stack thickness of the color filters, it is necessary to increase the thickness of each color filter in the stacked portion of the color filters. In order to increase the thicknesses of the second and third layered color filters, there is for example a method of reducing the leveling by speedily drying using a vacuum drying process or a method of increasing the coating film thickness of the resin. However, in these methods, coating blots or drying blots occur, so that production yield is lowered.

[0081]

FIG. 23 is a view showing a relation between the thickness (depicted in the horizontal axis) of the color filter in the pixel region and the height (depicted in the vertical axis) of the spacer (the overlapped color filters). The mark ▲denotes a case where the height of the color filter and the height of the protrusion are equal to each other and the mark □ denotes a case where the height of the protrusion is 2.0 μm. As shown in the figure, in order to sustain the cell gap at a value of 4 μm, both of the thickness of the color filters in the pixel region and the height of the protrusion need to be 3 μm. However, if the height of the protrusion is less than 30% of the cell gap or more than 50 % of the cell gap, the transmittance is lowered or the contrast deteriorates. For the reason, it is preferable that the height of the protrusion is in a range of 1.2 ~ 2.0 μm. In this case, there is a need to further increase the thickness of the color filters.

[0082]

In general, if the thickness of the pigment dispersive resist used as a material for the color filter is more than 3 μm, it is difficult to obtain a fine pattern.

In addition, the drying speed after the coating process decreases, there is a problem in that productively deteriorates. Therefore, it is not practicable that the thickness of the color filter is more than 3 μm. As a material for the color filter, a material having a poor evenness such as polyimide may be considered. However, since the polyimide is photo-insensitive, an etching process is needed for the pattering, so that the number of processes increases, and thus, production cost increases. In addition, even if the color filter is formed in a large thickness, the common electrode of the spacer portion and the pixel electrode of the TFT substrate is too close to each other, the short-circuit defect may easily occur.

[0083]

In the embodiment, as described above, the spacer 41a is formed on the stacked portion of the color filters 23R, 23G, and 23B, and the cell gap can be adjusted by using the spacer 41a. Therefore, although the thickness of the color filters 23R, 23G, and 23B is formed to be less than 3 μm, it is possible to obtain a sufficient cell gap. Now, a method of manufacturing the CF substrate 40 according to the embodiment will be described with reference to FIGS. 24 and 25.

[0084]

Firstly, as shown in FIG. 24(a), a photosensitive pigment dispersive type blue resist is coated on a glass substrate 21, and an exposure process and a developing process are performed, thereby forming a blue color filter 23B having a thickness of about 1.5 μm on a blue pixel region, a black matrix formation region, a spacer formation region (a region corresponding to each of intersection portions between gate bus lines and data bus lines in the TFT substrate), and each of the marks (positioning marks or the like).

[0085]

Next, as shown in FIG. 24(b), a photosensitive pigment dispersive type red resist is coated on a glass substrate 21, and an exposure process and a developing process are performed, thereby forming a red color filter 23R having a thickness of about 1.5 μm on a red pixel region, a black matrix formation region, and a spacer formation region. Next, as shown in FIG. 24(c), a photosensitive pigment dispersive type green resist is coated on a glass substrate 21, and an exposure process and a developing process are performed, thereby forming a green color filter 23G having a thickness of about 1.5 μm on a green pixel region, a black matrix formation region, and a spacer formation region.

[0086]

Next, as shown in FIG. 24(d), on the entire upper surface of the glass substrate 21, by forming ITO in a thickness of about 0.15 μm, a common electrode 26 is formed. In the embodiment, in the black matrix formation regions, two color filters are overlapped, and in the spacer formation region, three color filters are overlapped. In this case, although the thickness of the color filter is 1.5 μm in the pixel portion (a region corresponding to a first layered color filter), the thicknesses of the second and third layered color filters are smaller than the thickness thereof. At this time, the height (the height from the surface of the color filter in the pixel portion) of the stack of the three layered color filters in the spacer formation portion is about 1.8 μm, and the height (the height from the surface of the color filter in the pixel portion) of the stack of the two layered color filters in the black matrix formation portion is about 1.1 μm.

[0087]

Next, by using a spin coating method, a positive type photosensitive novolak resist having a thickness of 2.5 μm is coated on the entire upper surface

of the glass substrate 21. After that, by using a reticule corresponding to a spacer formation pattern having a width of 30 μm and a protrusion formation pattern having a width of 6 μm, the resist is stepper-exposed with a predetermined exposure amount, and then, a developing process is performed. By doing so, as shown in FIG. 25, the cell gap adjusting spacer 41a and the domain control protrusion 41b are formed. The thickness of the after-developing resist is about 2.0 μm in the spacer formation region and about 2.3 μm in the protrusion formation region.

[0088]

Next, by using an oven, a post-baking process is performed at a temperature of 220 □ in 1 hour. In the spacer formation portion, the after-baking film thickness is about 2.0 μm; the line width is about 30 μm. On the other hand, in the protrusion formation region, the resist is reflowed due to heat during the post-baking process, so that the thickness is about 1.5 μm and the line width is 10 μm. Therefore, desired profiles can be obtained. In the embodiment, the same effect as the first embodiment is obtained. In addition, there is an advantage in that, since the black matrix is formed by stacking the red and blue color filters, the Cr film formation process and the etching process are unnecessary in comparison to the first embodiment. As a result, it is possible to reduce production cost.

[0089]

In addition, in the above example, the spacer 41a and the protrusion 41b are formed by using the stepper exposure process. However, if a desired resolution can be obtained, the exposure can be performed by using a proximity exposure process or a mirror projection process. In addition, in the above example, the three layered color filters are overlapped in the spacer formation

portion, but not limited thereto. A single layered color filter or two layered color filters may be used in the spacer formation portion.

[0090]

(Sixth Embodiment)

Now, a sixth embodiment of the present invention will be described. The difference of the sixth embodiment from the first embodiment is that a method of forming the spacers and the protrusions of the CF substrate 20 is different. The other constructions are basically similar to those of the first embodiment, and thus, description of the same constructions will be omitted.

[0091]

FIG. 26 is a view showing a method of manufacturing a CF substrate of a liquid crystal display apparatus according to the sixth embodiment. Firstly, as shown in FIG. 26(a), on a glass substrate 21, a Cr film is formed, and the Cr film is patterned to form a black matrix 22. After that, on the glass substrate 21, color filters 23R, 23G, and 23B are substantially formed. Here, in the black matrix 22 of the spacer formation portion, the color filters 23R, 23G, and 23B are formed to be overlapped.

[0092]

After that, on the entire upper surface of the substrate 21, a common electrode 24 made of ITO is formed. Next, on the common electrode 24, by using a spin coating method or the like, a positive type novolak resist 42 is coated. Next, by using a reticle corresponding to a spacer formation pattern having a width of 30 μm and a protrusion formation pattern having a width of 6 μm, the resist 42 is exposed, and then, a developing process is performed. As a result, as shown in FIG. 26(a), spacer 42a and protrusions 42b are formed.

[0093]

Next, a post-baking process is performed at a temperature of 220 □ in 1 hour. Since the width of the protrusion 42b is narrow, the resist is reflowed due to heat during the post-baking process, so that the height of the protrusion 42b is smaller than the height of the spacer 42a as shown in FIG. 26(c). By doing so, the spacer 42a and the protrusion 42b having different heights are simultaneously formed. In the embodiment, the same effect as the first embodiment is obtained.

[0094]

In addition, in the embodiment, although the black matrix 22 is made of the Cr film, the black matrix 22 may be made of a black resin. In addition, in the above example, the three layered color filters 23R, 23G, and 23B are overlapped in the spacer formation portion, but not limited thereto. A single layered color filter or two layered color filters may be used in the spacer formation portion. However, if the step difference in the spacer formation region increases, the distance between the common electrode and the pixel electrode of the TFT substrate is shortened, so that short-circuit defect can easily occur. Therefore, it is preferable that the step difference of the spacer formation region is not too large.

[0095]

(Seventh Embodiment)

Now, a seventh embodiment of the present invention will be described. Conventionally, a black matrix has been made of a metal film such as Cr or a black resin. The OD value required for the black matrix is more than 2.5 in a normally white liquid crystal display apparatus and more than 2.0 in a normally black liquid crystal display apparatus. However, the OD value required for the black matrix changes depending on types of liquid crystal, the cell gap, structures

of the TFT substrate, and the like.

[0096]

On the other hand, as a method of forming a color filter, there are a dye method, a pigment dispersion method, an electro-deposition method, and a printing method. The dye method has a problem in that the number of processes increases. The electro-deposition method has a problem in that the management of the electro-deposition solution is difficult and the film formation state is not uniform. In the printing method, since the film thickness distribution or the pattern accuracy is not sufficient, the printing method is not practically used. Therefore, the pigment dispersion method is mainly used as a method forming the color filter.

[0097]

In the pigment dispersion method, by using a photoresist in which the pigment is dispersed, the resist is patterned with a photolithography technique. Therefore, conventionally, in order to form the CF substrate, a total of four photolithography processes are needed for one black matrix, and three RGB color filters. Therefore, production yield is lowered, and equipment and production costs increase.

[0098]

For these reason, an approach for reducing the Cr or black resin film formation process and the patterning process by forming the black matrix by overlapping at least two color filters of the three RGB color filters. However, in this case, when the photoresist is pattered, due to a reflected light generated from grooves of the stages of the exposure apparatus, the position of edge of the color filter slightly changes, so that display blots may occur.

[0099]

FIG. 27 is a schematic view showing an exposure process performed on the photoresist to be color filters. As shown in FIG. 27, a photoresist in which a pigment is dispersed is coated on a glass substrate 101, the glass substrate 101 is mounted on a stage 106 of the exposure apparatus, and a UV light is illuminated thereon through a mask on which a predetermined pattern is formed. In the stage 106 of the exposure apparatus, there are provided holes for sucking and fixing the substrate 101 or other groove (hereinafter, simply referred to as a groove). A light emitting from a light source and passing through the substrate 101 is reflected vertically on an even portion of the stage 106. On the other hand, light is reflected slantingly on the grooves 106a. As a result, the exposure amount in vicinity of the groove 106a changes, so that after a developing shape of the grooves 106a may be transferred on the resist pattern. Now, the shape of the grooves 106a transferred on the resist pattern is referred to as a stage trace. In general, with respect to a situation for forming positioning marks and a light shielding capability of the black matrix, the blue or red color filter is initially formed. In general, with respect to the OD value of the color filter, in case of a single color, the OD value of the blue (B) color filter is highest, the OD value of the green (G) color filter is equal to or less than the OD value of the red (R) color filter (B > R ≥ G). In addition, among cases of stacked color filters, the OD value of three stacked red, green, and blue color filters is highest, the OD value of two stacked red and blue color filters is next highest, and the OD value of two stacked red and green color filters is the next highest. The OD value of the two stacked blue and green color filters is equal to or less than the OD value of the two stacked red and green color filters (RGB > RB > RG ≥ BG). The following Table 1 shows the OD value and transmittance of general two or more stacked transparent color filters.

[0100]

[Table 1]

Stacked layer	OD Value	Transmittance
R+G	1.3	5.0 %
G+B	1.1	7.9 %
B+R	2.1	0.8 %
R+G+B	2.5	0.3 %

[0101]

FIG. 28 is a view showing a general example of a black matrix constructed by stacking the color filters. By doing so, the blue color filter 102B is formed on the glass substrate 101, the red color filter 102R is formed, and then, the green color filter 102G is formed. In this case, an edge of the blue pixel portion is defined by the edge of the red color filter 102R, an edge f the red pixel portion is defined by the edge of the blue color filter 102B, and an edge of the green pixel portion is defined by the edge of the blue color filter 102B.

[0102]

In a case where the blue color filter 102B is initially formed on the substrate 101, as described above, the blue color filter 102B is affected by the grooves 106a of the stage 106 of the exposure apparatus. In the liquid crystal display apparatus shown in FIG. 28, since the edges of the red pixle portion and the green pixel portion are defined by the edge of the blue color filter 102B, the traces of the red pixle portion and the green pixel portion occur. In this case, since the OD value of the stack of the blue color filter 102B and the red color filter 102R is higher than the OD value of the stack of the blue color filter 102B and the green color filter 102G, the trace of the stage more greatly occur in the red pixel portion.

In the blue pixel portion, since the edge thereof is defined by the second layered red color filter 102R, the trace of the stage cannot affect. In addition, although the trace of the stage is not almost seen in the individual pixels, the traces can be seen on the entire liquid crystal panel.

[0103]

Conventionally, although the trace of the stage is intended to be removed by using a surface treatment for the stage 106 or by controlling the positions of the grooves, since the holes for sucking the substrate is necessary, it is impossible to completely remove the grooves 106a from the stage 106. Therefore, in the embodiment, there is provided a method of manufacturing a liquid crystal display apparatus where the trace of the stage cannot easily occur.

[0104]

FIG. 29 is a cross sectional view showing a method of manufacturing a CF substrate of liquid crystal display apparatus according to the seventh embodiment. FIG. 30 is a plan view showing the method of manufacturing the CF substrate. In FIG. 30, dash lines denote a region (hereinafter, referred to as a red pixel portion) to be the red pixel portion, a region (hereinafter, referred to as a green pixel portion) to be the green pixel portion, and a region (hereinafter, referred to as a blue pixel portion) to be the blue pixel portion,

[0105]

Firstly, as shown in FIGS. 29(a) and 30(a), on the glass substrate 101, a photoresist containing a blue pigment having a thickness of about 1.5 μm is coated, and an exposure process and a developing process are performed to form the blue color filter 102B on the blue pixel portion B, surrounding portion thereof, the red pixel portion R, surrounding portion thereof, the green pixel

portion G, surrounding portion thereof, and a mark formation portion (not shown). As shown in FIG. 30(a), the blue color filter 102B is not formed in a predetermined range from the circumferential portion of the green pixel portion G.

[0106]

Next, as shown in FIGS. 29(b) and 30(b), on the glass substrate 101, a photoresist containing a red pigment having a thickness of about 1.5 μm is coated, and an exposure process and a developing process are performed to form the red color filter 102R on the red pixel portion R, surrounding portion thereof, the blue pixel portion B, surrounding portion thereof, and the green pixel portion G. As shown in FIG. 29(b), in the surrounding portion of the green pixel portion G, the red color filter 102R is formed at an inner side of the blue color filter 102B.

[0107]

Next, as shown in FIGS. 29(c) and 30(c), on the glass substrate 101, a photoresist containing a green pigment having a thickness of about 1.5 μm is coated, and an exposure process and a developing process are performed to form the green color filter 102G on the green pixel portion G and surrounding portion thereof. As shown in FIG. 29(c), in the surrounding portion of the green pixel portion G, the three layered color filters 102B, 102G, and 102B are stacked, and in the surrounding portion of the blue pixel portion B and the red pixel portion R, the two layered color filters are stacked.

[0108]

Next, as shown in FIG. 29(d), on the entire upper surface of the glass substrate 101, by forming ITO in a thickness of about 0.15 μm, a common electrode 103 is formed. If necessary, similar to the first embodiment, the spacer and the protrusion are formed on the CF substrate, and after that, an alignment

film (not shown) is formed on the entire upper surface of the substrate 101. By doing so, the CF substrate is completed.

[0109]

Next, the CF substrate and the TFT substrate are attached, and a liquid crystal is inserted between the substrates. By doing so, the liquid crystal display apparatus is completed. In the embodiment, as shown in FIG. 31, although the edge of the red pixel portion R is defined by the first layered blue color filter 102B, all the edges of the blue pixel portion B and the green pixel portion G are defined by the second layered red color filter 102R. Since the light is attenuated through the first layered blue color filter 102B, although there are the grooves in the stage of the exposure apparatus, the edge of the blue pixel portion B is not almost affected by the reflected light from the groove during the patterning of the red color filter 102R. In addition, although the edge of the green pixel portion G is affected by the grooves of the stage of the exposure apparatus, since the OD value of the stack of the red color filter 102R and the green color filter 102G is small, and since the color thereof is different from the color of the blue color filter 102B defining the edge of the red pixel portion R, the stage traces cannot easily seen.

[0110]

According to the embodiment, since the black matrix is formed by stacking the color filters, it is possible to further reduce production time and production cost in comparison to a case where the black matrix is made of a Cr film or a black resin. In addition, according to the embodiment, during the pattering of the color filters for defining the edges of the pixels, it is not almost affected by the reflected light from the stage of the exposure apparatus, so that it is possible to

manufacture a good display liquid crystal display apparatus with the stage trace reduced, even in a case where there are the groove in the stage of the exposure apparatus.

[0111]

In addition, in the embodiment, although the blue color filter 102B, the red color filter 102R, and the green color filter 102G are sequentially formed in this order, the color filters may be formed in the other orders by defining the edge of two or more of the three color pixel portions with the edge of the second layered color filter.

[0112]

In addition, in the embodiment, the invention according to Claim 8 is described with reference to a vertical liquid crystal display apparatus, but not limited thereto. The present invention may be applied to any other liquid crystal display apparatus where the black matrix is constructed by stacking two or more color filters.

[0113]

In addition, in the embodiment, a glass substrate is used as the substrate 101. In addition to this, an organic plate such as acryl material having a high UV absorbance (UV is a sensitive wavelength) is used as the substrate 101, so that the light passing through the substrate 101 is attenuated. Therefore, the affect of the grooves can be further reduced. In addition, as shown in FIG. 32, if a UV absorbing film 101a made of a UV absorbing material such as acryl is formed on the substrate 101, the same effect can be obtained.

[0114]

(Eighth Embodiment)

FIG. 33 is a cross sectional view showing a method of manufacturing a CF substrate of liquid crystal display apparatus according to the eighth embodiment. FIG. 34 is a plan view showing the method of manufacturing the CF substrate. In FIG. 34, dash lines denote a red pixel portion, a blue pixel portion, and a blue pixel portion. Firstly, as shown in FIGS. 33(a) and 34(a), on the glass substrate 101, a photoresist containing a green pigment having a thickness of about 1.5 μm is coated, and an exposure process and a developing process are performed to form the green color filter 102G on the green pixel portion G, surrounding portion thereof, surrounding portion of the red pixel portion R, and surrounding portion of the blue pixel portion B. As shown in FIG. 34(a), the green color filter 102G is not formed in a predetermined range from the circumferential portion of the red pixel portion R.

[0115]

Next, as shown in FIGS. 33(b) and 34(b), on the glass substrate 101, a photoresist containing a red pigment having a thickness of about 1.5 μm is coated, and an exposure process and a developing process are performed to form the red color filter 102R on the red pixel portion R, surrounding portion thereof, surrounding portion of the blue pixel portion B, and the green pixel portion G. As shown in FIG. 34(b), the red color filter 102R is not formed in a predetermined range from the circumferential portion of the blue pixel portion B.

[0116]

Next, as shown in FIGS. 33(c) and 34(c), on the glass substrate 101, a photoresist containing a blue pigment having a thickness of about 1.5 μm is coated, and an exposure process and a developing process are performed to form the blue color filter 102B on the blue pixel portion B, surrounding portion

thereof, surrounding portion of the green pixel portion G, and the red pixel portion R. As shown in FIG. 34(c), the blue color filter 102B is not formed in a predetermined range from the circumferential portion of the green pixel portion G.

[0117]

Next, similar to the seventh embodiment, on the entire upper surface of the glass substrate 101, a common electrode 103 made of ITO is formed. If necessary, the spacer and the protrusion are formed, and after that, an alignment film is formed on the entire upper surface of the substrate 101. By doing so, the CF substrate is completed. Next, the TFT substrate which is formed separately is attached to the CF substrate, and the liquid crystal is inserted between both substrates. By doing so, the liquid crystal display apparatus is completed.

[0118]

In the embodiment, as shown in FIG. 35, the edge of the green pixel portion G is defined by the edge of the second layered red color filter 102R, the edge of the red pixel portion R is defined by the edge of the second layered blue color filter 102B, and the edge of the blue pixel portion B is defined by the edge of the first layered green color filter 102G. Like this, since the edge of the pixel portions in the green pixel portion G and the red pixel portion R are defined by the edges of the second layered color filters, the edges of the pixel portions is very slightly affected by the reflected light from the stage of the exposure apparatus, so that the stage trace due to the reflected light from the stage of the exposure apparatus can be avoided. In addition, although the edges of the blue pixel portions is defined by the first layered green color filter 102G, as described in the seventh embodiment, since the OD value of the stack of the green color filter 102G and the blue color filter 102B is small, the stage traces cannot easily seen.

[0119]

In addition, a material for absorbing the UV light (for example, HALS (Hindered Amine Light Stabilizer)) may be added to a material for the green or red color filter, so that the affect of the reflected light from the stage can be further reduced. In addition, as described in the seventh embodiment, the substrata 101 may be made of an acryl resin plate or a film formed by coating the acryl resin plate on a glass substrate.

[0120]

In addition, in the embodiment, although the green color filter, the red color filter, and the blue color filter are sequentially formed in this order, the order of the color filters may be changed as the order of the red color filter and the blue color filter. In addition, in a liquid crystal display apparatus such as a normally black liquid crystal display apparatus where a low OD value required for the black matrix is allowable, the edge of the pixel portion may be located at a position indicated by (i) in FIG. 35. In addition, in a liquid crystal display apparatus such as a normally white liquid crystal display apparatus where a relatively high OD value required for the black matrix is allowable, the edge of the pixel portion may be located at a position indicated by (ii) in FIG. 35. By doing so, the embodiment can be applied to various liquid crystal panels.

[0121]

In addition, as shown in FIG. 6, the blue color filter 102B may extend up to the edge of the green pixel portion.

(Ninth Embodiment)

Now, a ninth embodiment of the present invention will be described. A volume of a liquid crystal inserted in the liquid crystal display apparatus is

changed by thermal expansion or contraction due to change in a temperature. For example, in an environment test, firstly the liquid crystal display apparatus is in an environment of a room temperature to - 20 □, and then, the temperature of the environment is changed up to 60 □. According to the test, the volume of the liquid crystal is changed as ± 0.1 μm which corresponds to the cell gap.

[0122]

In a case where an elastic force of the spacer cannot follow the thermal contraction of the liquid crystal, the pressure of the liquid crystal decreases. In a severe case, foams may be generated within the liquid crystal display apparatus (liquid crystal panel). In addition, since the pressure of the cell just after the liquid crystal is injected is generally lower than the atmospheric pressure, the spacer is pressed. However, when the liquid crystal is thermally expanded, if the elastic force of the spacer cannot follow the change in the cell gap, the interval is generated between the spacer and the substrate. Therefore, an elastic force needs to be changed in accordance with the pressure of the space.

[0123]

On the other hand, in a method of manufacturing a liquid crystal display apparatus, a pressure of about 5 atm is exerted on the entire liquid crystal panel within an autoclave. In addition, a user may push the screen with a finger to exert a high pressure partially on the liquid crystal display apparatus (so-called surface pushing). Like this, a high pressure is exerted on the liquid crystal display apparatus, the spacer may be too deformed to return to the original state. In addition, if a high pressure is exerted on the liquid crystal display apparatus, there may be short-circuit between the pixel electrode of the TFT substrate and the common electrode of the CF substrate. Therefore, there is a need to prevent an

excessive deformation of the spacer.

[0124]

Therefore, the embodiment is to provide a good display quality liquid crystal display apparatus capable of avoiding change in pressure of the liquid crystal depending on change in a temperature and preventing excessive deformation of the spacer even though a high pressure is exerted. FIG. 37 is a plan view of a CF substrate of a liquid crystal display apparatus according to the ninth embodiment. FIG. 38 is a cross sectional view taken along positions of the black matrix 222. In addition, in FIG. 37, the mark □ indicates a spacer 225a having a large height, and the mark O indicates a spacer 225b having a small height.

[0125]

The liquid crystal display apparatus according of the embodiment comprises a TFT substrate 210, a CF substrate 220, and a liquid crystal inserted between the substrates 210 and 220. The TFT substrate 210 is constructed as follows. Similar to the first embodiment, on a glass substrate 211, gate bus lines (not shown), data bus lines (not shown), and TFTs (not shown) are formed. On theses components, an insulating film (not shown) is interposed, and pixel electrodes 216 made of ITO are formed. In addition, on an upper surface of the glass substrate 211, an alignment film 217 is formed, and surfaces of the pixel electrodes 216 are covered with the alignment film 217.

[0126]

The CF substrate 220 is constructed as follows. On the lower surface of the glass substrate 221, a black matrix 222 is formed, and RGB color filters 223R, 223G, and 223B are formed corresponding to opening portions of the black matrix 222, that is, pixels regions. Under the color filters 223R, 223G, and 223B, a

common electrode 224 made of ITO are formed. Under the common electrode 224, spacers 225a and 225b made of a resin are formed. The spacers 225a and 225b are disposed to positions corresponding to intersection positions of the gate bus lines and the data bus lines of the TFT substrate 210. In addition, in the embodiment, as shown in FIGS. 37 and 38, the spacers 225a having a large height and the spacers 225b having a small height are alternately disposed. In addition, on the lower surface of the substrate 221, an alignment film 226 is formed, and surfaces of the common electrode 224 and the spacers 225a and 225b are covered with the alignment film 226.

[0127]

In the liquid crystal display apparatus, as shown in FIG. 38, a distal end portion of the spacers 225a are in contact with the TFT substrate 210 at a room temperature, and a distal end portion of the spacers 225b are separated from the TFT substrate 210. In the embodiment, the height (a height from the surface of the common electrode 224) of the spacers 225a is 4 μm, and the height (a height from the surface of the common electrode 224) of the spacers 225b is 3.8 μm

[0128]

Now, deformation of the spacers due to change in temperature and applied pressure will be described. In a case where the pressure of the cell is less than 1 atm, a pressing weight is exerted on the spacers 225a. If the pressing weight is low, the weight is exerted on only the spacers 225a, but not exerted on the spacers 225b. Therefore, only the spacers 225a are elastically deformed to cope with the change in pressure. In this case, the deformation amount of the spacers 225a with respect to the pressure can be adjusted by properly selecting a distribution density, cross section area, and material of the spacers 225a.

[0129]

In a case where a high pressure is partially exerted on the liquid crystal display apparatus or in a case where a large pressure is entirely exerted on the liquid crystal display apparatus within an autoclave, the cell gap is shortened; the spacers 225b as well as the spacers 225a are in contact with the TFT substrate 210. By doing so, the pressure is distributed to the spacers 225a and 225b, so that excessive deformation of the spacers 225a and 225b can be prevented.

[0130]

FIG. 39 is a view showing a change in a cell gap with respect to the pressing weight, wherein the horizontal axis denotes the pressing weight (air pressure) and the vertical axis denotes the cell gap. FIG. 39 shows some examples: an example where one spacer (having a constant height of 4 μm) per 3 pixels are disposed (density = 1/3); an example where one spacer (having a constant height of 4 μm) per 24 pixels are disposed (density = 1/24); and an example where one spacer (having a constant height of 4 μm) per 24 pixels and one spacer (having a constant height of 3.8 μm) per 3 pixels are disposed (density = 1/24 + 1/3). As shown in FIG. 39, in the example of density = 1/24 + 1/3, the spacers can smoothly follow the change in the cell gap in a pressing weigh range of less than 1 atm similar to the example of density = 1/24. In addition, in a high pressing weight range of more than 1 atm, similar to the example of density = 1/3, the change rate of the cell gap to the change in the pressure is lowered.

[0131]

Now, a method of manufacturing a liquid crystal display apparatus according to the embodiment will be described. FIGS. 40 and 41 are cross sectional views showing a method of manufacturing a CF substrate of the liquid

crystal display apparatus according to the embodiment. Firstly, as shown in FIG. 40(a), on the entire upper surface of the glass substrate 211, a Cr film having a thickness of 0.15 μm is formed, and by patterning the Cr film with a photolithography method, the black matrix 222 is formed.

[0132]

As shown in FIG. 40(b), by using a spin coating method, a blue pigment dispersed acryl resist (a negative type photoresist) is coated on the entire upper surface of the glass substrate 221, and an exposure process and a developing process are performed to form a blue (B) color filter 223B on a blue pixel portion and a black matrix 222 around the pixel portion. Next, as shown in FIG. 40(c), by using a spin coating method, a red pigment dispersed acryl resist (a negative type photoresist) is coated on the entire upper surface of the glass substrate 221, and an exposure process and a developing process are performed to form a red (R) color filter 223R on a red pixel portion and a black matrix 222 around the pixel portion.

[0133]

Next, as shown in FIG. 40(d), by using a spin coating method, a green pigment dispersed acryl resist (a negative type photoresist) is coated on the entire upper surface of the glass substrate 221, and an exposure process and a developing process are performed to form a green (G) color filter 223G on a green pixel portion and a black matrix 222 around the pixel portion. Next, as shown in FIG. 41(a), by using a sputter method, a common electrode 224 having a thickness of 0.15 μm is formed on the entire upper surface of the glass substrate 221, and the surfaces of the color filters 223R, 223G, and 223B are covered with the common electrode 224.

[0134]

Next, as shown in FIG. 41(b), by using a spin coating method, an acryl negative type photoresist is coated on the glass substrate 221, and an exposure process and a developing process are performed to form spacers 225 having a height of about 4 μm. In FIG. 41(b), one spacer 225a is formed per 3 pixels. However, as described above, one spacer may be formed per 24 pixels. The spacers 225a are formed at positions corresponding to intersection portions of the gate bus lines and the data bus lines of the TFT substrate.

[0135]

Next, as shown in FIG. 41(c), by using a spin coating method, an acryl negative type photoresist is coated on the glass substrate 221, and an exposure process and a developing process are performed to form spacers 225 having a height of about 3.8 μm. In FIG. 41(c), two spacers 225b are formed per 3 pixels. However, as described above, one spacer may be formed per 3 pixels. The spacers 225b are formed at positions corresponding to intersection portions of the gate bus lines and the data bus lines of the TFT substrate. In addition, the spacers 225b are formed at positions where the spacers 225a are not formed. In this case, the spacers 225a and the spacers 225b may be formed with the same material. Alternatively, the spacers 225a may be formed with a resin having a relatively low pressing strength (that is, a high elasticity), and the spacers 225b may be formed with a resin having a relative high pressing strength. In addition, the distribution density of the spacers 225a and the distribution density of the spacers 225b are properly selected according to the required specifications.

[0136]

After that, on the entire surface thereof, an alignment film made of

polyimide is formed, and the surfaces of the common electrode 224 and the spacers 225a and 225b are covered with the alignment film. By doing so, the CF substrate is completed. On the other hand, the TFT may be formed with the similar method according to the first embodiment, for example (see FIGS. 1 to 3). A metal film is formed on the glass substrate 221, and the metal film is patterned by using a photolithography method to form the gate bus lines and storage capacitance bus lines. After that, on the entire surface thereof, an insulating film is formed, and a silicon film to be an activation layer of the TFTs is formed thereon.

[0137]

Next, an insulating film is formed on the entire surface thereon. After that, a metal film is formed on the insulating film, and the metal film is patterned by using a photolithography to form data bus liens, source electrodes, and drain electrodes. Next, an insulating film is formed on the entire upper surface of the substrate 221, and an ITO film is formed on the insulating film. Next, the ITO film is patterned to form the pixel electrodes 216. After that, an insulating film 217 is formed on the entire surface thereof. By doing so, the TFT substrate is completed.

[0138]

The CF substrate 220 and the TFT substrate 210 are attached to each other, and a liquid crystal is inserted between the two substrates. By doing so, the liquid crystal display apparatus according to the embodiment is completed. In the embodiment, the material for the spacers 225a and 225b are an acryl resin, but limited thereto. A polyimide resin, a silica resin, an epoxy resin, a novolak resin, or the like may be used. In case of using the photo-insensitive resin such as novolak, after the photo-insensitive resin film is formed on the glass substrate 221, the photo-insensitive resin film is patterned by using a photoresist method.

[0139]

In addition, in the above embodiment, all the spacers 225a and 225b are formed on the CF substrate, but not limited thereto. The spaces 225a and 225b may be formed on the TFT substrate. In addition, one type of the spacers 225a and 225b may be formed on the TFT substrate, and the other type of the spacers 225a and 225b may be formed on the CF substrate. In addition, in the embodiment, the present invention is applied to a TN type liquid crystal display apparatus, but not limited thereto. The present invention may be applied to an STN (super twisted nematic) liquid crystal display apparatus, an MVA (multi vertical alignment) liquid crystal display apparatus, an IPS (in-panel switching) liquid crystal display apparatus, a ferroelectric liquid crystal display apparatus, semi-ferroelectric liquid crystal display apparatus, or the like.

[0140]

Now, optimal distribution density spacers will be described. As shown in FIG. 42, a pressing displacement measurement is performed on a spacer on which the three color filter 223R, 223G, and 223B, the common electrode 224 made of ITO, and the novolack resin film 228 are stacked. The measurement result is shown in FIG. 43. Here, the area of the upper portion of the spacer is 500 μm^2, and the black matrix is formed by stacking the three color filters 223R, 223G, and 223B.

[0141]

In this structure, a displacement amount is calculated with respect to the pressing weight of a liquid crystal panel which has a small displacement hysterisis at the highest weight of 50 mN. The result is shown in a curve of FIG. 44. In a case where the internal pressure of the cell of the liquid cyratl panel is obtained as

0.7 atm by controlling the liquid crystal injection amount, in a normal state, a weight of 0.3 atm is exerted on the spacers. If the external temperature changes from 25 □ to - 25 □ or from 25 □ to 60 □, the change in volume of the liquid crystal is reduced as the cell gap of about 0.1 μm. In an initial displacement corresponding to a low weight, there is a need for a displacement of ± 0.1 μm at the center of the displacement at the pressing weight of 0.3 atm. When the weight is low, the spacers may be an easy displacement one. According to FIG. 44, the density of the spacers is limited to a density of less than 1/6 (l spacer per 6 pixels) as an upper limit.

[0142]

On the other hand, in order to obtain a resistance to the high weight surface pressing, the displacement hysterisis of the resin is about 10% of the largest displacement. Therefore, in a large weight region, there is a need to suppress the displacement. The real surface pressing pressure is about 2 atm. In order to avoid blots, it is preferable that the pressing weight is in a range of 0.3 to 2 atm, and the displacement amount is less than 0.5 μm. By doing so the lower limit of the spacer density is limited, and as shown in FIG. 41, it is more than 1/2 (one spacer per 12 pixels).

[0143]

On the other hand, in an autoclave, in order to remove foams by reducing the volume of the cell by 5%, the spacers must be compressed down to about 0.2 μm. In the autoclave, a weight of about 5 atm is exerted on the liquid crystal panel. However, since the liquid crystal is hermetically sealed or since a sealing member is on the circumferential portion of the display portion, a real weight exerted on the spacer is about 1/2. Therefore, in order to reduce the displace

amount down to 0.5 μm or less, there is a need to reduce the spacer density down to 1/6 (one spacer per 6 pixels) or less.

[0144]

As a result, there is a need for the spacers which can be easily displaced in a low weight region but not easily displaced in a height weight region. In the embodiment, since the spacers have different heights, the requirement can be satisfied. In a case where a first spacer has a height of 4.0 μm and a density of 1/2 and a second spacer has a height of 3.7 μm and a density of 1/6, the corresponding displacement is indicated by "Hybrid" in FIG. 44. Like this, according to the spacer structure, the displacement amount is large in a pressing weight range of 0 ~ 1 atm, and the displacement amount is relatively small in a pressing weight range of 1 atm or more. Therefore, it is possible to implement a preferable spacer characteristic.

[0145]

(Tenth Embodiment)

FIG. 45 is a cross sectional view of a liquid crystal display apparatus according to a tenth embodiment of the present invention. The difference of the tenth embodiment from the ninth embodiment is that the spacer structure is different. The other constructions are basically similar to those of the ninth embodiment. And thus, in FIG. 45, the same reference numerals denotes the same components as those of FIG. 38, and description of the same constructions will be omitted,

[0146]

On the lower surface of the glass substrate 221, a black matrix 222 is formed, and RGB color filters 223R, 223G, and 223B are formed corresponding to

opening portions of the black matrix 222, that is, pixels regions. Under the color filters 223R, 223G, and 223B, a common electrode 224 made of ITO are formed. Under the common electrode 224, double layered spacer 225 made of resin films 225c and 225d are formed. The resin films 225c and 225d are constructed with materials having different elastic forces. For example, the resin film 225c is made of an acryl resin having a relatively high pressing strength (a low elastic force), and the resin film 225d is made of an acryl resin having a low pressing strength (a high elastic force). In addition, the spacers 225 are formed to intersection portions of the gate bus lines and the data bus lines of the TFT substrate 210. In FIG. 45, one spacer 225 is formed per one pixel. However, one spacer 225 may be formed per several pixels.

[0147]

In addition, on the lower surface of the substrate 221, an alignment film 226 is formed, and the surfaces of the common electrode 224 and the spacer 225 are covered with the alignment film 226. The distal end portion of the spacer 225 is in contact with the TFT substrate 210, so that the cell gap between the TFT substrate 210 and the CF substrate 220 is sustained in a constant thickness. In the embodiment, the spacer 225 is constructed with a two layered structure of a low elastic resin film 225c and a high elastic resin 225d. Therefore, when the pressing strength is relatively small, the resin film 225d is mainly elastically deformed and follows the change in the cell gap. In addition, when a large pressing strength, the strength is exerted on the resin film 225c as well as the resin film 225d. However, since the resin film 225c has a low elastic force, the deformation amount with respect to the pressing strength is small. By doing so, it is possible to prevent the spacer 225 from being too excessively deformed due to

the excessive strength. In the embodiment, the same effect as the ninth embodiment can be obtained.

[0148]

FIGS. 46 and 47 are cross sectional views showing a method of manufacturing a CF substrate 220 of the liquid crystal display apparatus according to the embodiment. Firstly, as shown in FIG. 46(a), on the entire upper surface of the glass substrate 211, a Cr film having a thickness of 0.15 μm is formed, and by patterning the Cr film with a photolithography method, the black matrix 222 is formed.

[0149]

As shown in FIG. 46(b), by using a spin coating method, a blue pigment dispersed acryl resist (a negative type photoresist) is coated on the entire upper surface of the glass substrate 221, and an exposure process and a developing process are performed to form a blue (B) color filter 223B on a blue pixel portion and a black matrix 222 around the pixel portion. Next, as shown in FIG. 46(c), by using a spin coating method, a red pigment dispersed acryl resist (a negative type photoresist) is coated on the entire upper surface of the glass substrate 221, and an exposure process and a developing process are performed to form a red (R) color filter 223R on a red pixel portion and a black matrix 222 around the pixel portion.

[0150]

Next, as shown in FIG. 46(d), by using a spin coating method, a green pigment dispersed acryl resist (a negative type photoresist) is coated on the entire upper surface of the glass substrate 221, and an exposure process and a developing process are performed to form a green (G) color filter 223G on a green

pixel portion and a black matrix 222 around the pixel portion. Next, as shown in FIG. 47(a), by using a sputter method, a common electrode 224 having a thickness of 0.15 μm is formed on the entire upper surface of the glass substrate 221, and the surfaces of the color filters 223R, 223G, and 223B are covered with the common electrode 224.

[0151]

Next, as shown in FIG. 47(b), by using a spin coating method, an acryl negative type photoresist is coated on the glass substrate 221, and an exposure process and a developing process are performed to form resin films 225c having a height of about 2.0 μm. In FIG. 47(b), one resin film 225c is formed per one pixel. However, as described above, one resin film may be formed per several pixels. The resin films 225c are formed at positions corresponding to intersection portions of the gate bus lines and the data bus lines of the TFT substrate.

[0152]

Next, as shown in FIG. 47(c), by using a spin coating method, an acryl negative type photoresist is coated on the glass substrate 221, and an exposure process and a developing process are performed to form resin films 225c having a height of about 2.0 μm on the resin film 225c. By doing so, a spacer 255 constructed with the resin films 225c and the resin films 225d is completed. In this case, the resin films 225d may be formed with a higher elastic material than the resin film 225c. In addition, the elasticity and thickness of the resin films 225c, 225c and the distribution density of the resin films 225 are properly selected according to the required specifications.

[0153]

After that, on the entire upper surface of the glass substrate 221, an

alignment film made of polyimide is formed, and the surfaces of the common electrode 224 and the spacers 225 are covered with the alignment film. By doing so, the CF substrate is completed. In addition, in the above embodiment, all the resin films 225a and 225b are formed on the CF substrate, but not limited thereto. The spaces 225c and 225c may be formed on the TFT substrate. In addition, one type of the resin films 225c and 225c may be formed on the TFT substrate, and the other type of the resin films 225c and 225c may be formed on the CF substrate.

[0154]

(Eleventh Embodiment)

FIG. 48 is a plan view of a liquid crystal display apparatus (MVA liquid crystal display apparatus) according to an eleventh embodiment of the present invention. The liquid crystal display apparatus is constructed with a TFT substrate 230, a CF substrate 240, and a vertically aligned liquid crystal 259 inserted between the two substrates 230 and 240.

[0155]

The TFT substrate 240 is constructed similar to the first embodiment (see FIG. 1). On a glass substrate 241, gate bus lines (not shown), data bus lines (not shown), storage capacitance bus lines (not shown) and TFTs (not shown) are formed. On theses components, an insulating film (not shown) is interposed, and pixel electrodes 236 made of ITO are formed. On the pixel electrode 236, similar to the first embodiment, slits (not shown) are formed. In addition, on an upper surface of the glass substrate 231, an alignment film 237 is formed, and surfaces of the pixel electrodes 236 are covered with the alignment film 237.

[0156]

The CF substrate 240 is constructed as follows. On the lower surface of the glass substrate 241, a black matrix 242 is formed. The black matrix 242 are formed in regions corresponding to the gate bus lines, data bus lines, and storage capacitance bus lines of the TFT substrate 230. On the lower surface of the glass substrate 241, RGB color filters 243R, 243G, and 243B are formed corresponding to opening portions of the black matrix 242, that is, pixels regions. In the embodiment, as shown in FIG. 49, under the lower side of the black matrix 242, three layered color filters 243R, 243G, and 243B are formed.

[0157]

In addtoin, under the lower sides of the color filters 243R, 243G, and 243B, a domain control protrusion 246 are formed in zigzag shape as shown in FIG. 48. In addition, resin films 246 are formed in a rate of one film per 3 pixels to intersection portions of the gate and date bus lines. The resin film 246a, as described later. and the protrusion 246a are simultaneously formed with the same material.

[0158]

In addition, resin films 247 are formed to intersection portions of the gate and date bus lines. In FIG. 48, a spacer 251 is constructed with the color filters 243R, 243G, and 243B stacked under the black matrix 242, the resin film 246b, and the resin film 247. In addition, in FIG. 48, a spacer 252 is constructed with the color filters 243R, 243G, and 243B stacked under the black matrix 242 and the resin film 247.

[0159]

On the lower surface of the substrate 241, an alignment film 248 is formed, and surfaces of the common electrode 245, the protrusions 246a, and the spacers

251 and 252 are covered with the alignment film 248. In addition, in the embodiment, a distal end portion of the spacers 251 are in contact with the TFT substrate 230 at a room temperature, and a distal end portion of the spacers 252 are separated from the TFT substrate 230.

[0160]

In the embodiment, the two types of spacers 251 and 252 having different heights copes with the change in the cell gap, so that the same effect as the ninth embodiment can be obtained. FIGS. 50 and 51 are views showing a method of manufacturing a CF substrate of the liquid crystal display apparatus according to the embodiment.

[0161]

Firstly, as shown in FIG. 50(a), on the glass substrate 241, a low reflectance Cr film having a thickness of 0.15 μm are formed, and a positive type photosensitive novolak resist (not shown) having a thickness of about 1.5 μm is coated thereon. Next, an exposure process and a developing process are performed, and by using the resist as a mask, the Cr film is etched to form the black matrix 242. After that, the resist is removed.

[0162]

As shown in FIG. 50(b), by using a spin coating method, a blue pigment dispersed acryl resist (a negative type photoresist) is coated on the entire upper surface of the glass substrate 241, and an exposure process and a developing process are performed to form a blue (B) color filter 243B having a thickness of 1.5 μm on a blue pixel portion and a spacer formation portion. Next, as shown in FIG. 50(c), by using a spin coating method, a red pigment dispersed acryl resist (a negative type photoresist) is coated on the entire upper surface of the glass

substrate 241, and an exposure process and a developing process are performed to form a red (R) color filter 243R having a thickness of 1.5 μm on a red pixel portion and a spacer formation portion. In the spacer formation portion, the color filter 243 is thinner.

[0163]

Next, as shown in FIG. 50(d), by using a spin coating method, a green pigment dispersed acryl resist (a negative type photoresist) is coated on the entire upper surface of the glass substrate 241, and an exposure process and a developing process are performed to form a green (R) color filter 243R having a thickness of 1.5 μm on a green pixel portion and a spacer formation portion. In the spacer formation portion, the color filter 243 is thinner.

[0164]

Next, as shown in FIG. 51(a), on the entire upper surface of the glass substrate 241, an ITO is sputtered to form a common electrode 245 having a thickness of 0.15 μm. After that, by using a spin coating method, on the common electrode 245, a positive type photosensitive novolak resist (not shown) having a thickness of about 1.5 μm is coated. Next, an exposure process and a developing process are performed to remain a resist in a predetermined pattern (a pattern of protrusions 246a and a pattern of spacers 251). After that, the resist pattern is post-baked at a temperature of 200 □. By doing so, as shown in FIG. 51(b), on the upper side of the substrate 241, the protrusions 246a and the resin films 246b are formed. In this case, the thickness of the stack of the color filters 243R, 243G, and 243B is about 1.7 μm, and the height (thickness) of the resin film 246b formed thereon is about 0.4 μm by leveling.

[0165]

After that, by using a spin coating method, on the entire upper surface of the glass substrate 241, a positive type photosensitive novolak resist (not shown) having a thickness of about 3 μm is coated. Next, an exposure process and a developing process are performed to remain a resist in a predetermined pattern (a pattern of spacers 251 and 252). By doing so, as shown in FIG. 51(c), on the upper side of the glass substrate 21, the resin film 247 is formed.

[0166]

After that, on the entire upper surface of the substrate 241, an alignment film 246 is formed. By doing so, the CF substrate is completed. The method of manufacturing the TFT substrate is the same as that of the first embodiment, so description thereon is omitted. According to the aforementioned method, two types of spacers 251 and 252 having a thickness difference of about 0.4 μm can be easily formed.

[0167]

In addition, in the embodiment, the black matrix 242 is a low reflectance Cr film, but limited thereto, and a black resin (about 1.0 μm) may be used. In the embodiment, the color filters 243R, 243G, and 243B are stacked on all the spacer formation portions, but not limited thereto, and if a predetermined cell gap can be ensured, a single layered filter or two layered filter can be used.

[0168]

In addition, by changing the number of stacked color filters, two different types of spacers may be formed. The method can be applied to a TN liquid crystal display apparatus having no domain control protrusion.

(Twelfth Embodiment)

Now, a twelfth embodiment of the present invention will be described. The

difference of the twelfth embodiment from the ninth embodiment is that a method of forming the CF substrate is different. Description of the same constructions will be omitted.

[0169]

FIGS. 52 and 53 are cross sectional views showing a method of manufacturing the CF substrate of the liquid crystal display apparatus according to the twelfth embodiment of the present invention. In addtoin, FIG. 54 is a plan view (a schematic view) of a CF substrate of a liquid crystal display apparatus according to the twelfth embodiment of the present invention. In FIG. 54, the mark □ indicates a spacer (having a large height) being in contact with the TFT substrate in a normal state, and the mark O indicates a spacer (having a small height) being in no contact with the TFT substrate in a normal state.

[0170]

Firstly, as shown in FIG. 52(a), on the entire upper surface of the glass substrate 261, a Cr film having a thickness of 0.15 μm is formed, and by patterning the Cr film with a photolithography method, the black matrix 262 is formed. As shown in FIG. 52(b), by using a spin coating method, a blue pigment dispersed acryl resist (a negative type photoresist) is coated on the entire upper surface of the glass substrate 261, and an exposure process and a developing process are performed to form a blue (B) color filter 263B on a blue pixel portion. Here, at a rate of one color filter per 3 pixels, the color filter 263B is formed on the black matrix 262. In the embodiment, the color filter 263B is formed on the black matrix 262 between the red and blue pixel portions. Next, as shown in FIG. 40(c), by using a spin coating method, a red pigment dispersed acryl resist (a negative type photoresist) is coated on the entire upper surface of the glass substrate 261,

and an exposure process and a developing process are performed to form a red (R) color filter 263R on a red pixel portion and a black matrix 262 around the pixel portion.

[0171]

Next, as shown in FIG. 52(c), by using a spin coating method, a red pigment dispersed acryl resist (a negative type photoresist) is coated on the entire upper surface of the glass substrate 261, and an exposure process and a developing process are performed to form a red (R) color filter 263R on a red pixel portion. In this case, the color filter 263R is not remained on the black matrix 262.

[0172]

Next, as shown in FIG. 52(d), by using a spin coating method, a green pigment dispersed acryl resist (a negative type photoresist) is coated on the entire upper surface of the glass substrate 261, and an exposure process and a developing process are performed to form a green (G) color filter 263G on a green pixel portion. In this case, the color filter 263G is not remained on the black matrix 262.

[0173]

Next, as shown in FIG. 53(a), on the entire upper surface of the glass substrate 261, by using a spin coating method, ITO having a thickness of about 0.15 μm is deposited to form common electrode 264. Next, as shown in FIG. 53(b), by using a spin coating method, on the glass substrate 261, for example, 4μm photoresist film 265 is formed. In this case, on the black matrix 262 between the blue pixel portion and red pixel portion, a color filter 263B is formed. On the other hand, on the black matrix 262 between the red pixel portion and green pixel portion and between the green pixel portion and the blue pixel portion, the color

filter is not formed, so that there occurs a step difference on the surface of the resist film 262.

[0174]

After that, an exposure process and a developing process are performed to pattern resist film 265, and as shown in FIG. 53(c), on the upper side of the black matrix 262, the spacer 265a is formed. In this case, the spacer 2654a between the blue pixel portion and the red pixel portion has a different height corresponding to the step difference between the color filter 223R, 223G and black matrix 262 in comparison to the spacers 265a between red pixel portion and the green pixel portion and between the green pixel portion and the blue pixel portion. By doing so, the spacers having different heights can be simultaneously formed with the same material.

[0175]

After that, on the entire upper surface of the separate 261, an alignment film (not shown) is formed, and the surfaces of the CF substrate 264 and the spacer 265a are covered with the alignment film. According to the embodiment, the same effect as the ninth embodiment can be obtained.

(Thirteenth Embodiment)

Now, a thirteenth embodiment of the present invention will be described. In the embodiment, if a spacer distribution density is n (number/cm2), if a displacement amount is x when a force of 9.8/n(N) is exerted on one spacer, if an average distance between two substrate is d, and if the liquid crystal density is q_{60}(g/cm^3) at 60 □ and q_{-20}(g/cm^3) at -20□, the spacer is formed so that the following inequality (1) for the displacement amount is stratified.

[0176]

$x/d > (1/q_{60} - 1/q_{-20})/(1/q_{60})$ (1)

In addition, in a case where at -20 □, the liquid crystal density cannot be determined, and at 20 □, the liquid crystal density can be determined, the spacer may be formed so that the following inequality (2) is satisfied.

$x/d > 2^* (1/q_{60} - 1/q_{20})/(1/q_{60})$ (2)

Now, the reasons will be described.

[0177]

In a conventional method of dispersing a square or bar shaped spacers, the liquid crystal molecule alignment is disturbed in a pixel region. However, in the first embodiment where the pillar shaped spacers are formed between the TFT and CF substrates, since alignment disturbance cannot occur in the pixel region, a high quality image can be obtained. If the pillar shaped spacer has elasticity, in a high temperature environment, the liquid crystal display apparatus is thermally expanded, and the distance between the spacer and the substrate is two separated from each other. Hereinafter, the effect is referred to as an excessively high temperature effect. On the contrary, in a low temperature environment, the liquid crystal display apparatus is thermally contracted. Hereinafter, the effect is referred as a low temperature foaming effect.

[0178]

In order to prevent the high temperature excessiveness and the low temperature foaming, the pillar shape spacer must have elasticity to follow the thermal expansion and contraction of the liquid crystal. In a case where the spacer is formed with a photoresist resin, the spacer itself has the elasticity. FIG. 55 is a view showing a weight displacement characteristic of a spacer, wherein the horizontal axis denotes pressing displacement amount and the vertical axis

denotes pressing weight, and wherein the relation between the displacement and weight per one spacer. As shown in FIG. the spacers made of photoresist resin change depending on the weight, but by adjusting the distribution density, the weigh and displacement amount per one spacer can be adjusted.

[0179]

The inventors search the high temperature excessiveness and the low temperature foaming by changing the spacer distribution density in the XGA (1024X768) 15 liquid crystal display apparatus. FIG. 56 shows the result. In addition, the average value d of the cell gap is 4 μm. In addition, the density 141 number/cm^2 corresponds to a case where the spacers are formed at a rate of one spacer per 24 pixels. The density 283 number/cm^2 corresponds to a case where the spacers are formed at a rate of one spacer per 12 pixels. The density 567 number/cm^2 corresponds to a case where the spacers are formed at a rate of one spacer per 6 pixels. The density 1133 number/cm^2 corresponds to a case where the spacers are formed at a rate of one spacer per 3 pixels. The density 3400 number/cm^2 corresponds to a case where the spacers are formed at a rate of one spacer per one pixel.

[0180]

At 60□, the density q60 shows about 0.97g/cm3, and at -20□, density q-20 shows 1.03g/cm3. Therefore, the right hand of the equation (1) is 0.058. As shown in FIG. 56, if the value x/d is larger than 0.058 (No 1, No 2, No 3), the high temperature excessiveness and the low temperature foaming cannot occur. If less than 0.958 (N o4, No 5), the high temperature excessiveness and the low temperature foaming occur.

[0181]

Therefore, in the embodiment, in order to satisfy the equation (1) and (2), the material and density of the spacer are selected. For example, a liquid crystal display apparatus where a pillar shaped spacer is formed on one of the TFT and CF substrates 10 and 20 (in FIG. 57(a), CF substrate 20) as shown in FIG. 57(a) or a liquid crystal display apparatus where a pillar shaped spacer is formed on both of the TFT and CF substrates 10 and 20 as shown in FIG. 57(b), the material and density of the spacers 25a and 25b satisfies the equations (1) and (2).

[0182]

In addition, in FIGS. 57(a) and (b), the TFT substrate 10 comprises a glass substrate 11, pixel electrodes 16a formed thereon, TFTs (not shown), gate bus lines (not shown), and data bus lines (not show). The CF substrate 20 comprises a glass substrate 21, black matrix 22 formed under the substrate color filters 23, and a common electrode 24. In addition, a liquid crystal 29 is inserted between the TFT and CF substrates 10 and 20.

[0183]

In the embodiment, the material is not limited to a specific one. For example, a polyimide resin, a phenol resin, a novolak resin, and an acryl resin may be used.

(Fourteenth Embodiment)

Now, a fourteenth embodiment will be described.

[0184]

FIG. 58 is a cross sectional view of a TFT substrate of a liquid crystal display apparatus according to a fourteenth embodiment of the present invention. FIG. 59 is an enlarged view of a vicinity of a TFT formation portion. In FIG. 58, a resin film (protrusion) is selectively formed on an insulating film 318 of FIG. 59,

and a distal end portion of the protrusion is in contact with the CF substrate to maintain the cell gap in a constant value.

[0185]

The liquid crystal display apparatus comprises a TFT substrate 310, a CF substrate 320, a liquid crystal 329 inserted between the TFT and CF substrates 310 and 320. The TFT substrate 310 is construed as follows. On the glass substrate 311, gate bus lines 312 are formed, and on the gate bus lines 312, an insulating film (gate insulating film) 313 is formed. In the embodiment, as shown in FIGS. 58 and 59, the insulating film 313 is not formed in the pixel region.

[0186]

On the insulating film 313, a silicon film 314 to be TFT activation layer is selectively formed. In addition, on the silicon film 314, gate bus lines 312 and a channel protective film (insulating film) 315 having the same width as the gate bus lines 312 are formed. In a region from both ends of the channel protective film 315 to the both ends of silicon film 314, n type impurities are doped with a high density, so that n+ silicon film 316 is formed. In addtoin, on the silicon film 316, a three-layered conduction film (data bus lien, source electrode, and drain electrode) constructed with a Ti (titan) film 317a, a Al (aluminum) film 317b and a Ti film 317c a is formed.

[0187]

The silicon film 314, the channel protective film 315, the n+ type silicon film 316 and the conductive film 317 are covered with an insulating film (final protective film) 318. The insulating film 318 is also not formed on the pixel region. On the insulating film 318, a contact hole 318a is formed to reach to the source electrode (conductive film 317) of the TFTs. The pixel electrode 319 is formed in a

pixel region extending from contact hole 318a on the glass substrate 311 and electrically connected to the conductive film 317 of the source of the TFTs through the contact hole 318a. The pixel electrode 319 is made of ITO.

[0188]

In addition, on the entire surface of the glass substrate 311, an alignment film (not shown) is formed, and the surfaces of the pixel electrode 319 and insulating film 318 is covered with the alignment film. On the other hand, the CF substrate 320 is constructed as follows. In a blue pixel region of the lower surface of the glass substrate 321, a blue color filter 323B is formed. In a red pixel region, a red color filter 323R is formed, and in a green pixel region, a green color filter 323G is formed. In addition, in a region between the pixels on the lower surface of the glass substrate 321, three-layered color filters 323B, 323R, 323G are stacked to form a black matrix.

[0189]

Under the color filters 323B, 323R, 323G, a common electrode 324 made of ITO is formed. In addition, under the common electrode 324, an alignment film (not shown) is formed. In the embodiment, since the insulating films 313, 318 are not formed in the pixel regions, although the height of the cell gap adjusting spacer facing the insulating film 318, a predetermined cell gap can be obtained. By doing so, the cell gap adjusting spacer can be easily formed. In addition, the thickness of the liquid crystal display apparatus can be reduced by the thickness of the insulating films 313, 318.

[0190]

Now, a method of manufacturing a liquid crystal display apparatus according to the embodiment will be described. The method of manufacturing the

CF substrate is the same as a conventional method. In FIG. 58, instead of the CF substrate, the CF substrate described in the first embodiment may be used. Therefore, description on the method of manufacturing the CF substrate is omitted. FIGS. 60 and 61 are cross sectional views showing a method of manufacturing the TFT substrate of the liquid crystal display apparatus according to the embodiment.

[0191]

Firstly, as shown in FIG. 60(a), on the glass substrate 311, an 0.15 μm conductive film made of, for example, Al(aluminum), Ti (titan), a stack thereof, or Cr is formed, and by using a photolithography method, the conductive film is patterned to form gate bus lines 312 and storage capacitance bus lines (not shown). After that, on the glass substrate 311, a SiNx having a thickness of about 0.35 μm is deposited to form an insulating film (gate insulating film) 313.

[0192]

Next, on the insulating film 313, an amorphous silicon film 314 (to be TFT activation layer) having a thickness of about 0.03 μm is formed. In addition, on the amorphous silicon film 314, the SiNx is deposited with a thickness of about 0.15 μm. Next, on the SiNx film, a photoresist is coated, and the photoresist is exposed from the lower surface of the glass substrate 311. After that, an exposure process is performed to remain the resist film on only the upper portion of the gate bus lines 312. By using the resist film as a mask, the SiNx film is etched to selectively form, as shown in FIG. 60(b), the channel protective film 315 on the silicon film 314. After that, the resist film on the channel protective film 315 is removed.

[0193]

Next, on the glass substrate 311, an n+ type amorphous silicon film doped with n type impurities is formed with a thickness of about 0.03 μm. After that, on the n+ amorphous silicon film, an about 0.02 μm Ti film, an about 0.08 μm Al film, an about 0.05 μm Ti film are sequentially stacked to form a conductive film, that is, a stack of the Ti film, Al film, and Ti film. Next, by using a photolithography method, in a shape shown in FIG. 60(c), the conductive film 317, the n+ type amorphous silicon film 316, and the amorphous silicon film 314 are patterned.

[0194]

Next, as shown in FIG. 61(a), on the entire upper surface of glass substrate 311, an insulating film (final protective film) 318 made of SiNx are formed with a thickness of about 0.33 μm. After that, by using a photolithography method, a contact hole reaching to TFT 의 source electrode (conductive film 317) is formed on the insulating film 318, and the insulating films 318, 313 on the pixel regions are removed. For example, a dry etching method may be used. As a condition of the dry etching, a gas may be SF6/O2 =150/250 (sccm), pressure may be 8.0 Pa, and a power may be 600 W.

[0195]

Next, as shown in FIG. 61(b), an ITO film is formed on the substrate 311, and by using a photolithography method, the ITO film is patterned to form a pixel electrode 319. After that, on the entire upper surface of substrate 311, an alignment film made polyimide is formed with a thickness of 0.05 ~ 0.1 μm. By doing so, the TFT substrate 310 is completed.

[0196]

In addition, in the embodiment, the insulating films 313, 318 on the red pixel region, the green pixel region, and the blue pixel region are completely removed.

However, as shown in FIG. 62, in one or two of the red pixel region, the green pixel region, and the blue pixel region, the insulating films 313, 318 may be remained. By doing so, the so-call multi cell gap liquid crystal display apparatus where the cell gap is adjusted for each color can be implemented. For example, as shown in FIG. 62, in the blue pixel region, the insulating films 313, 318 are remained, in the red pixel region and the green pixel region; the insulating films 313, 318 are removed. Therefore, the cell gaps between the blue pixel and red pixel and between the blue pixel and the green pixel have a difference of about 0.68 μm. In the multi cell gap liquid crystal display apparatus, the optical characteristics are optimized by adjusting the cell gaps for respective color pixels, so that it is possible to further improve the display quality. Here, as shown in FIG. 63, the insulating film 318 between the source electrode and pixel region of the TFT may be removed. By doing so, the step difference of the pixel electrode 319 from the source electrode to the pixel region is shorted, so that the connection defect can be prevented.

[0197]

In addition, by controlling the etching condition for the insulating films 313, 318, a desired thickness of the insulating films 313, 318 may be remained in the pixel region. In addition, in the above example, all the insulating films 313, 318 are formed with an inorganic material (SiNx). However, the insulating films may be formed with an insulating organic material. For example, in a case where the insulating film 318 is formed with a resin material such as acryl, polyimide, and epoxy, by using a spin coating method, the material is formed with a thickness of about 1 μm, and after that, at the same time of forming the contact hole 318a, the resin material is selectively removed form the pixel region. By doing so, similar to

the above example, formation of the cell gap in the pixel region and a multi cell gap structure can be implemented. In this case, since the step difference between colors changes depending on change in the thickness of the insulating film 318, by changing the thickness of the insulating film 318 during a spin coating method, the cell gap can be simply adjusted.

[0198]

In the embodiment, if the cell gaps are equal to each other, the interval between the glass substrates 311 and 321 is shorted in comparison to a conventional liquid crystal display apparatus where the insulating films 313, 318 are not formed. Therefore, after the TFT substrate 310 and the CF substrate 320 are attached with a seaming member, in the liquid crystal injection method, a long production time is taken. However, in the so-called dropping method where, for example, the liquid crystal is dropped on the TFT substrate 310, the CF substrate 320 is disposed on the TFT substrate 310, and then, the TFT substrate 310 and the CF substrate 320 are attached, the production can be reduced.

[0199]

(Fifteenth Embodiment)

FIG. 64 is a cross sectional view showing a liquid crystal display apparatus according to a fifteenth embodiment. The liquid crystal display apparatus comprises a TFT substrate 310, a CF substrate 320, and a liquid crystal inserted between the TFT substrate 310 and the CF substrate 320.

[0200]

TFT substrate 310 basically has the same construction as the fourteenth embodiment, except that the final protective film 331 is a photo-sensitive acryl resin. Namely, on the glass substrate 311, the gate bus lines 312 are formed, and

on the gate bus lines 312 and the pixel region, the insulating film (gate insulating film) 313 is formed.

[0201]

On the insulating film 313, similar to the fourteenth embodiment, the silicon film to be a TFT activation layer and the conductive layer to be data bus lines, the source electrode, and the drain electrode are formed (see FIG. 59). In addition, on the TFTs, a final protective film 331 made of a resin is formed. The final protective film 331 serves as a spacer. Namely, a distal end portion of the final protective film 331 is in contact with the CF substrate 340 to maintain the cell gap in a constant value.

[0202]

In the distal end portion of TFT source electrode, the final protective film is removed. On a region from the end portion of the source electrode to the insulating film 313 of the pixel region, the pixel electrode 319 made of ITO is formed. The surfaces of the final protective film 331 and pixel electrode 319 are covered with an alignment film (not shown). On the other hand, the CF substrate 340 is constructed as follows. On the lower surface of the glass substrate 341, a black matrix 342 made of a metal such as Cr or a black resin is formed. With the black matrix 342, the gate bus lines, the data bus lines, and the TFTs of TFT substrate 310 are covered. In addition, in a pixel region on the lower surface of the CF substrate 340, red(R), green (G), and blue (B) color filters 343R, 343G, and 343B are formed corresponding to the pixel electrodes on the TFT substrate 310.

[0203]

In addition, a common electrode 344 made of ITO is formed on the lower

sides of the black matrix 343 and the color filters 343R, 343G, 343B. In addition, under the common electrode 344, an alignment film (not shown) is formed. FIG. 65 is a cross sectional view showing a method of manufacturing the TFT substrate. Firstly, similar to the fourteenth embodiment, on the glass substrate 311, gate bus lines 312, gate insulating film 313, a silicon film 314, a channel protective film 315, and n+ type silicon film 316, and a conductive film 317 are formed (see FIGS. 60(a) to 60(c)).

[0204]

Next, as shown in FIG. 65(a), by using a spin coating method, on the entire upper surface of the substrate 311, a photosensitive acryl resin is coated with a thickness of about 4 μm to form the photosensitive acryl resin film 330. Next, as shown in FIG. 65(b), the photosensitive acryl resin is exposed and developed to form a final protective film 331 for covering the conductive film 317 and silicon films 314, 316. Here, the final protective films 331 are removed from the conductive film 317 of the TFT source and the pixel region.

[0205]

After that, on the entire upper surface of the glass substrate 311, an ITO film is formed, and the ITO film is patterned to form a pixel electrode 319. Next, on the entire upper surface of the glass substrate 311, an alignment film (not shown) is formed, and the surfaces of the pixel electrode 319 and the final protective film 331 are covered with the alignment film. By doing so, the TFT substrate 310 is completed. The CF substrate can be manufactured by using a well know method, so that description thereon is omitted.

[0206]

In the embodiment, since the final protective film 331 is made of a

photosensitive acryl resin, the thick film can be easily formed with a thickness of about 4 μm. In addition, the distal end portion of the thick final protective film 331 is in contact with the CF substrate 340 to maintain the cell gap in a constant value of about 4 μm. In other words, the final protective film 331 serves as a spacer. The cell gap is defined by the thickness of the photosensitive acryl resin, and the thickness of the photosensitive acryl resin can be arbitrarily selected by adjusting the coating condition thereof. In addition, by selectively removing the gate insulating film 313 of the pixel region depending on pixel colors, the multi cell gap can be implemented.

[0207]

According to the embodiment, the same constructions and effects as the fourteenth embodiment can be obtained. In addition, since the final protective film 331 can be used as a spacer, the production process can be simplified, and the production cost can be reduced. In addition, as described above, the multi cell gap can be implemented, and a liquid crystal display apparatus having optimal optical characteristics such as chroma, transmittance, and contract can be manufactured.

[0208]

Now, a sixteenth embodiment of the present invention will be described. FIG. 66 is a plan view showing a before-injection state of a liquid crystal display apparatus (liquid crystal panel) according to the sixteenth embodiment. FIG. 67 is a cross sectional view taken along line D-D'. In addition, in FIG. 67, the gate bus liens and the data bus lines are omitted, and the same reference numerals denotes the same components as those of FIG. 1.

[0209]

The CF substrate 420 of the liquid crystal display apparatus according to the embodiment is constructed as follows. On the one surface of the glass substrate 421 (on the lower surface in FIG. 67), a red color filter 423R, a green color filter 423G and a blue color filter 423B are formed with predetermined patterns. In addition, in the embodiment, as shown in FIG. 67, two color filters of the color filters 423R, 423G, 423B are stacked to form a black matrix for shielding inter-pixel regions. In addition, in the shielding region 402 outside of a display region, a black matrix constructed with a stack of the blue color filter 423B and the red color filter 423R is formed. In addition, on the shielding region 402 in the vicinity of the liquid crystal injection inlet 404, a plurality of gap sustaining spacers 425c are formed. In addition, in the liquid crystal injection inlet 404, a plurality of pillars constructed with there-layered color filters 423R, 423G, 423B are formed, and under the pillars, gap sustaining spacers 425d are formed. In addition, distal end portions of the spacers 425c and 425d are in contact with the TFT substrate 410 to maintain the gaps in the liquid crystal injection inlet 404 and the shielding region 402 in a constant value.

[0210]

The TFT substrate 410 and the CF substrate 420 are attached to each other with a sealing member 40 coated in a region outside the display region 401. After that, through the liquid crystal injection inlet 404, the liquid crystal is injected between the TFT substrate 410 and the CF substrate 420. In general, for the liquid crystal injection, a vacuum chamber is used. Namely, the TFT substrate and the CF substrate are attached with the sealing member to form a liquid crystal panel, and then, the liquid crystal panel together with a liquid crystal container is inserted within the vacuum chamber. After the vacuum in the chamber is formed,

the liquid crystal injection inlet is immersed into the liquid crystal, and the pressure of the chamber is returned to the atmospheric pressure. By doing so, due to the pressure difference, the liquid crystal is injected into a space in the liquid crystal panel. After a sufficient amount of the liquid crystal is injected into the liquid crystal panel, the liquid crystal injection inlet is molded with a resin.

[0211]

For example, as shown in FIG. 22, in the liquid crystal display apparatus, since the black matrix is constructed by stacking the color filters, the production process can be further simplified in comparison to a method of forming the black matrix using Cr or the like. In addition, since the cell gap adjusting spacer is formed at a predetermined position, the cell gap in the display region can be maintained in a constant value. However, in a shielding region outside of the display region, the interval between the TFT substrate and the CF substrate is shortened in comparison to a liquid crystal display apparatus where the black matrix is formed with Cr. For the reason, the liquid crystal injection speed deviation increases depending on the liquid crystal panels. As a result, the injection time increases, the foams may be generated due to the insufficient injection. In addition, the cell gap may increases due to excessive injection.

[0212]

In order to solve the problem, the injection time for respective liquid crystal panels may be adjusted. However, if the injection time is adjusted for the respective liquid crystal panels, the product efficiency greatly decreases and the production cost increases. On the other hand, in the embodiment, as shown in FIG. 67, the spacers 425d and 425c are provided to the liquid crystal injection inlet 404 and the surrounding regions, and the gap between the TFT substrate 410 and

the CF substrate 420 can be maintained in a constant value by means of the spacers 425c and 425d. Therefore, the deviation of the liquid crystal injection time can be reduced, so that the aforementioned problem can be solved.

[0213]

FIGS. 68 to 70 are cross sectional views showing a method of manufacturing a CF substrate of a liquid crystal display apparatus according to the sixteenth embodiment. FIGS. 71 and 72 are plan views of the method of manufacturing the CF substrate. In FIGS. 71 and 72, the shape of the black matrix is also shown. In FIGS. 68 to 70, the color filter formation surface is an upper side of the figure. Firstly, on the entire upper surface of the glass substrate 421, a blue photoresist is coated. After that, by using a predetermined pattern mask, the photoresist is exposed and developed , as shown in FIGS 68(a) and 71(a), to form a blue pixel portion, a black matrix formation portion on the blue pixel portion, surroundings of the blue pixel portion, and surroundings of the red pixel portion, a spacer formation portion in the display region (see FIG. 22), a shielding region outside of the display region, and a blue color filter 423B with a thickness of 1.7 μm on the spacer formation portion of the liquid crystal injection inlet.

[0214]

Next, on the entire upper surface of the glass substrate 421, a red photoresist is coated. After that, by using a predetermined pattern mask, the photoresist is exposed and developed, as shown in FIGS 68(b) and 71(b), to form a red pixel portion, a black matrix formation portion on pixel portions, a spacer formation portion in the display region, a shielding region outside of the display region, and a red color filter 423R with a thickness of 1.7 μm on the spacer

formation portion of the liquid crystal injection inlet.

[0215]

In this case, since the thickness of the red color filter 423R stacked on the blue color filter 423B in the display region is narrow (10 ~ 40 μm), by using leveling during the pre-baking and post-baking processes, the thickness can be reduced less than 1.7 μm. On the other hand, since the thickness of the blue color filter 423B stacked on the red color filter 423R in the shielding region 402 and the liquid crystal injection inlet 404 is sufficiently large, the thickness is almost equal to the thickness of the red color filter 423R in the pixel region.

[0216]

Next, on the entire upper surface of the glass substrate 421, a green photoresist is coated. After that, by using a predetermined pattern mask, the photoresist is exposed and developed, as shown in FIGS 69(a) and 72(a), to form a green pixel portion, a black matrix formation portion on surroundings of the green pixel portion, a spacer formation portion in the display region 401, and a green color filter 423G with a thickness of 1.7 μm on the spacer formation portion of the liquid crystal injection inlet.

[0217]

In this case, since the thickness of the green color filter 423G stacked on the blue color filter 423B or the red color filter 423G in the display region is narrower than the width of the stacked portion, by using leveling during the pre-baking and post-baking processes, the thickness can be reduced less than 1.7 μm. On the other hand, since the thickness of the green color filter 423G stacked on the red color filter 423R in the liquid crystal injection inlet 404 is sufficiently large, the thickness is almost equal to the thickness of the green color filter 423G in the

pixel region.

[0218]

Next, as shown in FIG. 69(b), on the upper portion of the glass substrate 421, a common electrode 424 made of ITO is formed with a thickness of about 0.1 μm, and the surfaces the color filters 423R, 423G, 423B of the display region 401 and the surface of the color filter 423R of the shielding region 402 are covered with the common electrode 424. However, the common electrode is not formed in the liquid crystal injection inlet 404.

[0219]

Next, on the entire upper surface of the glass substrate 421, a photoresist is coated. Next, by using a predetermined pattern mask, the resist is exposed and developed, as shown in FIG. 70 and 72(b), to form domain control protrusion 425a on the color filter 423R, 423G, 423B in the display region 401, and at the same time, toe a cell gap adjusting spacer 425b in a predetermined position of display region 401, to form a gap sustaining spacer 425c in a predetermined position of shielding region 402, and to form a gap sustaining spacer 425d on a pillar constructed with three layered color filters 423B, 423R, 423G of the liquid crystal injection inlet 404.

[0220]

In this case, by adjusting pattern widths of the domain control protrusion 425a in the display region 401 and the cell gap adjusting spacer 425b in the display region 401, and pattern widths of the gap sustaining spacer 425c in the shielding region and the gap sustaining spacer 425d in the liquid crystal injection inlet 404, the height (the height from the surface of the substrate 421) of the spacers 425c, 425d is formed to larger than those of the domain control protrusion

425a and the cell gap adjusting spacer 425b. For example, the height of the cell gap adjusting spacer 425b in the display region 401 is 5.6 μm, the height of the spacer 425c of the shielding region 402 outside of the display region is 5.8 μm, the height of the spacer 425d of the liquid crystal injection inlet 404 is 6.0 μm. Like this, the heights of eh spacers 425b, 425c, 425d are different.

[0221]

After that, on the upper side of the glass substrate 421, an alignment film (not shown) is formed with a thickness of 800□, the surfaces of the color filters 423R, 423G, 423B, and the surfaces of the domain control protrusion 425a and the spacers 425b, 425c are covered with the alignment film. By doing son, the CF substrate 420 is completed. The TFT substrate 410 is the same as that of the first embodiment. Therefore, description on the method of manufacturing the TFT substrate 410 is omitted.

[0222]

Along the circumference of the CF substrate 420, a sealing member is coated, and the distal end portion of the spacers 425b, 425c, 425d are in contact with the TFT substrate 410 to attach the TFT substrate 410 and the CF substrate 420, so that a liquid crystal panel 400 is obtained. However, the sealing member is not coated on the liquid crystal injection inlet 404. After the attachment, the inner space between the TFT substrate 410 and the CF substrate 420 is connected to an external space.

[0223]

After that, the liquid crystal panel 400 and the liquid crystal container are inserted into the vacuum chamber, and the chamber is in vacuum. Next, the liquid crystal injection inlet 404 is immersed into the liquid crystal, and then, the

pressure of the chamber is returned to the atmospheric pressure. By doing so, the liquid crystal is injected into the internal space of the liquid crystal panel 400 due to the pressure difference. Here, in the embodiment, since the spacers 425d and 425c are not formed in the liquid crystal injection inlet 404 and surroundings thereof, although the interval between the TFT substrate 410 and the CF substrate 420 is relatively large, and although the black matrix is formed by stacking the color filters, the liquid crystal injection speed is high.

[0224]

Next, after a sufficient amount of the liquid crystal is injected into the liquid crystal panel, the liquid crystal injection inlet 404 is charged with a UV cured resin, and the liquid crystal injection inlet 404 is molded by UV illumination. Here, the UV cured resin is contacted, so that gaps in the liquid crystal injection inlet 404 and the shielding region 402 are shorted. By doing so, the gaps are uniform over the liquid crystal panel.

[0225]

By doing so, the cell gap is uniform at about 4.0 μm over the liquid crystal panel. After that, on the upper and lower sides of the liquid crystal panel, polarizing plates are adhered with a crossed Nichols. By doing so, a liquid crystal display apparatus is completed. An injection time test for a liquid crystal display apparatus manufactured according to the method shows that the embodiment can shorten the liquid crystal injection item by about 20% in comparison to a liquid crystal display apparatus where spacers are not provided to the shielding region 402 and the liquid crystal injection inlet 404 에 spacer.

[0226]

[Annex]

(1) In a method of manufacturing a liquid crystal display apparatus according to Claim 2, it is preferable that a post-baking process is performed after the developing process.

(2) In a method of manufacturing a liquid crystal display apparatus according to Claim 2, in the exposure process, the exposure amounts for the spacer formation region and the protrusion formation region may be different from each other.

[02227]

(3) In a method of manufacturing a liquid crystal display apparatus according to Claim 2, it is preferable that the transmittances of the spacer pattern and the protrusion pattern are different from each other.

(4) In a method of manufacturing a liquid crystal display apparatus according to Claim 2, in the exposure process, by performing a plurality of the exposure processes on the mask while the mask is shifted in a direction parallel to the photoresist film, the exposure amounts for the spacer formation region and the protrusion formation region may be different from each other.

[0228]

(5) In a method of manufacturing a liquid crystal display apparatus according to Claim 2, in the exposure process, by using a refracted light, the exposure amounts for the spacer formation region and the protrusion formation region may be different from each other.

(6) In a liquid crystal display apparatus according to Claim 8, it is preferable that the edge of the green pixel is defined by the edge of the red color filter formed on the green color filter, the edge of the red pixel is defined by the edge of the blue color filter formed on the red color filter, and the edge of the blue pixel is

defined by the edge of the first-layer green color filter.

[0229]

(7) In a liquid crystal display apparatus according to Claim 8, the edge of the green pixel may be defined by the edge of the red color filter formed on the green color filter, the edge of the red pixel may be defined by the edge of the blue color filter formed on the red color filter, and the edge of the blue pixel may be defined by the edge of the first-layer green color filter.

[0230]

(8) In a method of manufacturing a liquid crystal display apparatus according to Claim 10, it is preferable that the substrate is made of a material having a higher UV absorbing capability than a glass.

(9) In a method of manufacturing a liquid crystal display apparatus according to Claim 10, it is preferable that a UV absorbing material is added to at least one of the first color filter and the second color filter.

[0231]

(10) In a method of manufacturing a liquid crystal display apparatus according to Claim 10, on the surface of the substrate, a thin film made of a material having a better UV absorbing capability than the material of the substrate may be formed.

(11) In a method of manufacturing a liquid crystal display apparatus according to Claim 10, it is preferable that the black matrix is formed by stacking at least two color filters.

[0232]

(12) In a liquid crystal display apparatus according to Claims 23 or 24, the thickness of the final protective film interposed on the pixle region may be different

depending on colors of the pixels.

(13) In a liquid crystal display apparatus according to Claims 23 or 24, the final protective film is made of an insulating inorganic material.

[0233]

(14) In a liquid crystal display apparatus according to Claims 23 or 24, the final protective film is made of an insulating organic material.

(15) In a method of manufacturing a liquid crystal display apparatus according to Claim 25, the thickness of the first insulating film remained on the pixel region or the second insulating film may be changed depending on colors of the pixels.

[0234]

(16) In a method of manufacturing a liquid crystal display apparatus according to Claim 25, an upper portion of the thin film transistor among the second insulating film may be used as a spacer for sustaining the cell gap.

(17) In a method of manufacturing a liquid crystal display apparatus according to Claim 25, the second insulating film may be made of an inorganic material.

[0235]

(18) In a method of manufacturing a liquid crystal display apparatus according to Claim 25, the second insulating film may be made of an organic material.

(19) In a method of manufacturing a liquid crystal display apparatus according to Claim 28, it is preferable that, in a case where the red, green, and blue color filters are stacked as three layers, the domain control protrusion and the cell gap adjusting spacer are simultaneously formed thereon, and the first and

second substrates are attached to each other, a distal end portion of the cell gap adjusting spacer is in contact with the second substrate.

[0236]

(20) In a method of manufacturing a liquid crystal display apparatus according to Claim 28, it is preferable that, at the same time of forming the first gap sustaining spacer, a second gap sustaining spacer is formed on a black matrix outside the display region.

(21) In a method of manufacturing a liquid crystal display apparatus according to Claim 28, it is preferable that the first gap sustaining spacer is formed to be higher than the second gap sustaining spacer.

[0237]

[Effect]

Accordingly, by simultaneously forming a spacer for maintaining a cell gap in a constant value and a domain control protrusion having a lower higher than the spacer by using a photoresist film, it is possible to easily form a liquid crystal display apparatus having a good viewing characteristics.

[00238]

In addtoin, in a liquid crystal display apparatus where a black matrix is constructed by stacking two or more of red, green color filters, by defining edges of two or more of red, green, and blue pixels with edge of the upper layered color filter, the position change of the edges of pixels caused by reflected light from a stage of an exposure apparatus can be avoided. By doing so, it is possible to improve display quality of the liquid crystal display apparatus.

[0239]

In addition, first and second spacers having different heights is formed, the

cell gap is maintained by only the first spacers in a normal state, and the cell gap is maintained by both of the first and second spacers when a high pressure is exerted. By doing so, the deterioration in the display quality caused by the thermal expansion and contraction of the liquid crystal due to change in temperature can be avoided. In addition, the deformation of the spacers or the short-circuit of the pixel electrode and the common electrode caused by a high pressure within such as autoclave can be avoided. Even in a case where the apparatus is constructed by stacking a plurality of film having different pressing displacement, the same effect can be obtained.

[0240]

In addition, by selecting materials and density of the spacers wherein a displacement amount with respect to a weight satisfies a predetermined an inequality equation, the spacers can be properly extend or contract depending on thermal expansion or contraction of liquid crystal due to change in temperature. By doing so, the deterioration in display quality caused by the thermal expansion and contraction of the liquid crystal can be avoided. In addition, in at least one pixel region of a plurality of color pixels, by using a structure where a final protective film is not provided between the pixel electrode and the transparent substrate, or a structure where the thickness of the final protective film interposed between the pixel electrode and the transparent substrate is smaller than that of the final protective film on the thin film transistor, although the height of the cell gap adjusting spacer is lowered, a predetermined cell gap can be obtained. By doing so, the cell gap adjusting spacer can be easily formed.

[0241]

In addition, a pillar is formed by stacking two or more color filters in the

liquid crystal injection inlet, and a spacer is formed on the pillar. By doing so, the gap of the liquid crystal injection inlet can be ensured, so that deviation of the liquid injection time can be avoided. Therefore, the deterioration in display quality caused by the foams generated due to insufficient liquid crystal injection or the non-uniformity of the cell gap due to excessive injection can be avoided.

[Brief Description of Drawings]

[FIG. 1]

FIG. 1 is a cross sectional view of a liquid crystal display apparatus according to a first embodiment of the present invention.

[FIG. 2]

FIG. 2 is an enlarged view of a spacer formation portion in the liquid crystal display apparatus.

[FIG. 3]

FIG. 3 is a plan view of a TFT substrate of the liquid crystal display apparatus.

[FIG. 4]

FIG. 4 is a plan view of a CF substrate of the liquid crystal display apparatus.

[FIG. 5]

FIG. 5 is a view showing an example 1 of a method of manufacturing the CF substrate of the liquid crystal display apparatus according to the first embodiment of the present invention.

[FIG. 6]

FIG. 6 is a view showing an example 2 of a method of manufacturing the CF substrate of the liquid crystal display apparatus according to the first

embodiment of the present invention.

[FIG. 7]

FIG. 7 is a view showing an example 3 of a method of manufacturing the CF substrate of the liquid crystal display apparatus according to the first embodiment of the present invention.

[FIG. 8]

FIG. 8 is a view showing an example 4 of a method of manufacturing the CF substrate of the liquid crystal display apparatus according to the first embodiment of the present invention.

[FIG. 9]

FIG. 9 is a view showing an example 5 of a method of manufacturing the CF substrate of the liquid crystal display apparatus according to the first embodiment of the present invention.

[FIG. 10]

FIG. 10 is a view showing a method of manufacturing a CF substrate of a liquid crystal display apparatus according to a second embodiment of the present invention, wherein a positional relation between a light-shielding pattern of a mask and a pixel is shown.

[FIG. 11]

FIG. 11 is a view showing a method of manufacturing a CF substrate of a liquid crystal display apparatus according to a second embodiment of the present invention, wherein after-formation spacer and protrusion patterns are shown.

[FIG. 12]

FIG. 12(a) is a cross sectional view taken along line B-B of FIG. 11, and FIG. 12(b) is a cross sectional view taken along line C-C of FIG. 11.

[FIG. 13]

FIG. 13 is a view showing a method of manufacturing a CF substrate of a liquid crystal display apparatus according to a second embodiment of the present invention, wherein a cross sectional view of a protrusion formation region is shown.

[FIG. 14]

FIG. 14 is a view showing a method of manufacturing a CF substrate of a liquid crystal display apparatus according to a second embodiment of the present invention, wherein a cross sectional view of a spacer formation region is shown.

[FIG. 15]

FIG. 15 is a view showing a method of manufacturing a CF substrate of a liquid crystal display apparatus according to a second embodiment of the present invention, wherein a pattern exposure is shown in case of a resist used for an exposure amount corresponding to a after-developing film thickness of 1.5 μm which is 1.2 times of a normal exposure amount.

[FIG. 16]

FIG. 16 is a view showing a method of manufacturing a CF substrate of a liquid crystal display apparatus according to a third embodiment of the present invention, wherein a schematic view of an exposure process is shown.

[FIG. 17]

FIG. 17 is a view showing a method of manufacturing a CF substrate of a liquid crystal display apparatus according to a third embodiment of the present invention, wherein a view of a protrusion formation pattern is shown.

[FIG. 18]

FIG. 18 is a view showing a method of manufacturing a CF substrate of a

liquid crystal display apparatus according to a third embodiment of the present invention, wherein a schematic view of a protrusion formation region in an exposure process is shown.

[FIG. 19]

FIG. 19 is a view showing a method of manufacturing a CF substrate of a liquid crystal display apparatus according to a third embodiment of the present invention, wherein a method of forming a protrusion by using a pattern made of low transmittance material is shown.

[FIG. 20]

FIG. 20 is a view showing a method of manufacturing a CF substrate of a liquid crystal display apparatus according to a fourth embodiment of the present invention, wherein a schematic view of an exposure process is shown.

[FIG. 21]

FIG. 21 is an enlarged view of a protrusion formation region of FIG. 20.

[FIG. 22]

FIG. 22 is a cross sectional view of a liquid crystal display apparatus according to a fifth embodiment of the present invention.

[FIG. 23]

FIG. 23 is a view showing a relation between a thickness of a color filter and a height of a spacer.

[FIG. 24]

FIG. 24 is a view showing an example 1 of a method of manufacturing a CF substrate according to the fifth embodiment of the present invention.

[FIG. 25]

FIG. 25 is a view showing an example 2 of a method of manufacturing a CF

substrate according to the fifth embodiment of the present invention.

[FIG. 26]

FIG. 26 is a view showing a method of manufacturing a CF substrate according to a sixth embodiment of the present invention.

[FIG. 27]

FIG. 27 is a schematic view showing an exposure process for a photoresist to form a color filter.

[FIG. 28]

FIG. 28 is a view showing a general example of a black matrix formed by stacking a color filter.

[FIG. 29]

FIG. 29 is a cross sectional view showing a method of manufacturing a CF substrate according to a seventh embodiment of the present invention.

[FIG. 30]

FIG. 30 is a plan view showing a method of manufacturing a CF substrate.

[FIG. 31]

FIG. 31 is a view showing the seventh embodiment, wherein an edge of a color filter defining an edge of a pixel portion is shown.

[FIG. 32]

FIG. 32 is a view showing the seventh embodiment, wherein a substrate on which a UV absorbing film is formed is shown.

[FIG. 33]

FIG. 33 is a cross sectional view showing a method of manufacturing a CF substrate of a liquid crystal display apparatus according to an eighth embodiment of the present invention.

[FIG. 34]

FIG. 34 is a plan view showing a method of manufacturing a CF substrate.

[FIG. 35]

FIG. 35 is a view showing an example 1 of the eighth embodiment, wherein an edge of a color filter defining an edge of a pixel portion is shown.

[FIG. 36]

FIG. 36 is a view showing an example 2 of the eighth embodiment, wherein an edge of a color filter defining an edge of a pixel portion is shown.

[FIG. 37]

FIG. 37 is a schematic plan view of a liquid crystal display apparatus according to a ninth embodiment of the present invention.

[FIG. 38]

FIG. 38 is a cross sectional view taken along a position of a black matrix of a liquid crystal display apparatus.

[FIG. 39]

FIG. 39 is a view showing a calculation result of change in a cell gap with respect to a pressing weight.

[FIG. 40]

FIG. 40 is a view showing an example 1 of the ninth embodiment, wherein an edge of a color filter defining an edge of a pixel portion is shown.

[FIG. 41]

FIG. 41 is a view showing an example 2 of the ninth embodiment, wherein an edge of a color filter defining an edge of a pixel portion is shown.

[FIG. 42]

FIG. 42 is a view showing a liquid crystal display apparatus having spacers

constructed by forming a novolak resin film on a color filter.

[FIG. 43]

FIG. 43 is a view showing a pressing displacement curve of a spacer having a structure of FIG. 42.

[FIG. 44]

FIG. 44 is view showing a calculation result of a displacement amount of a resin spacer with respect to a pressing weight.

[FIG. 45]

FIG. 10 is a cross sectional view of a liquid crystal display apparatus according to a tenth embodiment.

[FIG. 46]

FIG. 46 is a view showing an example 1 of a method of manufacturing the CF substrate of the liquid crystal display apparatus according to the tenth embodiment of the present invention.

[FIG. 47]

FIG. 47 is a view showing an example 2 of a method of manufacturing the CF substrate of the liquid crystal display apparatus according to the tenth embodiment of the present invention.

[FIG. 48]

FIG. 48 is a plan view of liquid crystal display apparatus according to an eleventh embodiment of the present invention.

[FIG. 49]

FIG. 49 is a cross sectional view of the liquid crystal display apparatus.

[FIG. 50]

FIG. 50 is a view showing an example 1 of a method of manufacturing the

CF substrate of the liquid crystal display apparatus according to the eleventh embodiment of the present invention.

[FIG. 51]

FIG. 51 is a view showing an example 2 of a method of manufacturing the CF substrate of the liquid crystal display apparatus according to the eleventh embodiment of the present invention.

[FIG. 52]

FIG. 52 is a view showing an example 1 of a method of manufacturing the CF substrate of the liquid crystal display apparatus according to the twelfth embodiment of the present invention.

[FIG. 53]

FIG. 53 is a view showing an example 2 of a method of manufacturing the CF substrate of the liquid crystal display apparatus according to the twelfth embodiment of the present invention.

[FIG. 54]

FIG. 54 is a plan view (a schematic view) of a CF substrate of a liquid crystal display apparatus according to the twelfth embodiment of the present invention.

[FIG. 55]

FIG. 55 is a view showing a weight displacement characteristic of a spacer.

[FIG. 56]

FIG. is a view showing a result of testing a high temperature overflow and a low temperature forming depending on a change in a spacer distribution density.

[FIG. 57]

FIG. 13 is a view showing an example of a cell gap sustaining spacer of a

liquid crystal display apparatus according to a thirteenth embodiment of the present invention.

[FIG. 58]

FIG. 58 is a cross sectional view of a TFT substrate of a liquid crystal display apparatus according to a fourteenth embodiment of the present invention.

[FIG. 59]

FIG. 59 is an enlarged view of a vicinity of a TFT formation portion.

[FIG. 60]

FIG. 60 is a cross sectional view showing an example 1 of a method of manufacturing the TFT substrate of the liquid crystal display apparatus according to the fourteenth embodiment of the present invention.

[FIG. 61]

FIG. 61 is a cross sectional view showing an example 2 of a method of manufacturing the TFT substrate of the liquid crystal display apparatus according to the fourteenth embodiment of the present invention.

[FIG. 62]

FIG. 62 is a view showing an modified example of the fourteenth embodiment, wherein an insulating film under a pixel electrode of a blue pixel portion is remained and insulating films under pixel electrodes of red and green pixel portions.

[FIG. 63]

FIG. 63 is a view showing an example of the fourteenth embodiment, wherein an insulating film is etched to expose a conductive film for a source of the TFT.

[FIG. 64]

FIG. 64 is a cross sectional view showing a liquid crystal display apparatus according to a fifteenth embodiment of the present invention.

[FIG. 65]

FIG. 65 is a cross sectional view showing a method of manufacturing a TFT substrate of a liquid crystal display apparatus according to the fifteenth embodiment.

[FIG. 66]

FIG. 66 is a plan view showing a before-injection state of a liquid crystal display apparatus according sixteenth embodiment of the present invention.

[FIG. 67]

FIG. 67 is a cross sectional view taken along line D-D' of FIG. 66.

[FIG. 68]

FIG. 68 is a view showing an example 1 of a method of a liquid crystal display apparatus according to the sixteenth embodiment of the present invention.

[FIG. 69]

FIG. 69 is a view showing an example 2 of a method of a liquid crystal display apparatus according to the sixteenth embodiment of the present invention.

[FIG. 70]

FIG. 70 is a view showing an example 3 of a method of a liquid crystal display apparatus according to the sixteenth embodiment of the present invention.

[FIG. 71]

FIG. 71 is a plan view showing an example 1 of a method of a liquid crystal display apparatus according to the sixteenth embodiment of the present invention.

[FIG. 72]

FIG. 72 is a plan view showing an example 2 of a method of a liquid crystal

display apparatus according to the sixteenth embodiment of the present invention.

[FIG. 73]

FIG. 73 is a cross sectional view (a schematic view) showing an example of a conventional MVA liquid crystal display apparatus.

[FIG. 74]

FIG. 74 is a cross sectional view (a schematic view) showing a voltage applied state of the MVA liquid crystal display apparatus of FIG. 73.

[FIG. 75]

FIG. 75 is a cross sectional view (a schematic view) showing another example of a conventional MVA liquid crystal display apparatus.

[Reference Numerals]

10, 101, 210, 220, 230, 310, 321, 410, 510: TFT substrate

11, 21, 221, 231, 241, 261, 311, 421, 511, 521: glass substrate

12a, 312: gate bus line

13, 313: insulating film (gate insulating film)

14a: data bus line

15, 318, 331: insulating film (final protective film)

16a, 216, 236, 319, 516: pixel electrode

16b, 516a: slit (slit of pixel electrode)

17, 26, 217, 226, 237, 248: alignment film

18: TFT,

18a, 314, 316: silicon film

18b: source electrode

18c: drain electrode

20, 220, 240, 320, 420, 520: CF substrate

22, 222, 242, 262, 342, 522: black matrix

23R, 23G, 23B, 102R, 102G, 102B, 223R, 223G, 223B, 243R, 243G, 243B, 263R, 263G, 263B, 323R, 323G, 323B, 343R, 343G, 343B, 423R, 423G, 423B, 523: color filter

24, 103, 224, 245, 264, 324, 344, 424, 524: common electrode

25, 42, 102: resist

25a, 25c, 25d, 41a, 42a, 225a, 225b, 225, 251, 252, 265a, 425c, 425d: spacer

25b, 41b, 42b, 246a, 247a: protrusion

27, 28, 31, 32, 33, 34: mask

29, 219, 259, 329, 529: liquid crystal

32a: opening portion

106: exposure stage

228: novolak resin film

225c, 225d, 246b, 247: resin film

265: resist film

318: insulating film

314: channel protective film

317: conductive film

401: display region

402: light shielding region

403: sealing member

404: liquid crystal injection hole

425b: cell gap adjusting spacer

425c, 425d: cell gap sustaining spacer

425a, 517: domain control protrusion